Forecasting Drought in Puerto Rico with the Standard Precipitation Index

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Abstract *— The main premise of the current effort is that the use of a drought index, such as Standard Precipitation Index (SPI), may lead to a more appropriate understanding of drought duration, magnitude and spatial extent in Puerto Rico. The importance of the Index may be marked in its simplicity and its ability to identify the beginning and end of a drought event. Thus, it may point towards drought contingency planning and through it to drought alert mechanism. The present approach examines the SPI drought index application for important stations throughout Puerto Rico and it is evaluated accordingly by historical precipitation data. Different time series of data from 7 precipitation station, covering the period 1970-2014 and for time scales of 1,3,6,9 and 12 months, were used. The computation of the index was achieved by the appropriate usage of a pertinent software tool. The results underline the potential that the SPI usage exhibits in a drought alert and forecasting effort as part of a drought contingency planning posture.*

Key Terms *— Drought Contingency Planning, Drought Index, Geo-Statistical Methods, Standard Precipitation Index.*

INTRODUCTION

Drought is an extended period when a region receives below average precipitation. It has many effects on human activities, human lives and various elements of the environment. Conventionally, decrease of precipitation is considered as the origin of drought. [1] This leads to a reduction of storage of water and fluxes involved in the hydrological cycle depending on the choice of the hydrological or agricultural. It may also be explained as an unexpected reduction in precipitation over period of time in an area which is not necessarily arid. Characterizing periods of deficit and drought has been an important aspect of planning and management of water resources systems for many decades. These events are one of the most harmful natural disasters that affected the human population over time.

By having low precipitation levels, it can lead to severe hydrologic deficits. These deficits may impact on low crop yields for agriculture, replenished ground water resources, depletion in lakes/reservoirs, and shortage of drinking water and, reduced fodder availability etc., which can negatively impact on local populations. [2] Consequently, the ability to forecast and predict the characteristics of droughts, especially their frequency, monitoring and severity are important. Drought assessment and monitoring is necessary for water resource management as well as for the agricultural industry.

To overcome the impacts of drought an effectively and timely monitoring system is required. Effective monitoring of droughts can aid in developing an early warning system. An objective evaluation of the drought condition in a particular area is the first step for planning water resources in order to prevent and reduce the impacts of future occurrences of drought.

JUSTIFICATION

Puerto Rico has been facing a periods of drought on which each event passes by they are bigger in magnitude. By this problem affecting the population last year, agencies aren’t takin sufficient steps to predict future events and to have more knowledge about the subject. The selection of program is based primarily on that it hasn’t been used completely to monitor and predict drought because of the lack of interest to make studies overall from stations around Puerto Rico. [3] By using this program to evaluate, monitor the statistics of drought and precipitation for a period of 44 years, it can be used to predict future events of drought and to effectively make conscience to the people of Puerto Rico for the preparation of future events of drought. The system is one accessible for the evaluation of different areas around Puerto Rico with the only variable of importance, which is precipitation. With the use of the program, not only used for analyzing past behaviors of nature and high events of hi precipitations but it can also be used to predict future events using probability models and with methods of calculating the period of return. Evaluating past data and making future predictions it can be useful for making awareness of the subject and prepare people for such drastic events in the future.

LITERATURE REVIEW

Droughts are caused by situations with temporarily less than normal water availability. They are present in every hydro climatic region and appear in different components of the hydrological cycle. One thing all droughts have in common, is that they are caused by a deviation from normal conditions. [4] These deviations can be in precipitation, soil moisture, streamflow or groundwater. Droughts can be classified into meteorological, soil moisture and hydrological droughts. Meteorological droughts are characterized by a lack of precipitation, often combined with higher than normal potential evapotranspiration, for a long period of time and over a large area. Soil moisture droughts are caused by a deficit in soil moisture created by a high potential evapotranspiration and low precipitation.

Hydrological drought can occur in both groundwater and streamflow. Groundwater droughts can be the result of long periods with below average precipitation. While streamflow droughts can be caused by shorter periods with no precipitation, due to the fact that surface runoff or other quick flows can be a large component of the streamflow. [5]

Meteorological Drought Indicators

Three examples of soil meteorological drought indicators commonly used on the field are:

Rainfall Deciles

The theory of rainfall deciles was first introduced by Gibbs & Maher (1967). Monthly aggregated data of precipitation (rain and snow) are compared with average values extracted from long term observations. The method uses precipitation deciles, which are created with ranked observed precipitation. [6]

Standard Precipitation Index

The SPI calculation is done with monthly precipitation, which is fitted to a two parameter gamma probability distribution. This distribution is then transformed into a normal distribution. [7]

Effective Drought Index

A method to calculate drought on a daily time scale is the Effective Drought Index (EDI). It was developed by Byun & White (1999) to calculate daily water accumulation with a weighting function of time passage. The equations to calculate the EDI can be found in Section 3.5.1. Daily rain, - and snowfall data from time series of 30 years or more are used for the calculation of the EDI. [8]

Soil Moisture Drought Indicators

Three examples of soil moisture drought indicators commonly used on the field are:

Palmer Drought Severity Index

The Palmer Drought Severity Index (PDSI) was developed by Palmer (1965) to provide an index based on drought severity that allowed the comparison of droughts with different time and spatial scales. Palmer (1965) based his index on the supply-on-demand concept of the water balance. The PDSI takes into account precipitation, evapotranspiration, and soil moisture, although it is still classified by many authors as a meteorological drought indicator. [9]

Soil Moisture Deficit Index

They developed a drought index, which could detect short-term dry conditions, has no dependency on the season, and which has no reference to a climate region. The SMDI is used for the calculation of agricultural droughts and is used on a weekly time scale. The only variable used in the SMDI is the simulated or observed soil moisture content. [10]

Soil Moisture Content

The soil moisture content can be used as a indicator for soil moisture droughts (Tallaksen & van Lanen, 2004). When soil moisture content is below a predefined threshold the site is in a drought. The threshold method can also be applied to soil moisture content. Simulated soil moisture content in combination with the threshold approach has been used on a global scale. [10]

Hydrological Drought Indicators

Three examples of soil hydrological drought indicators commonly used on the field are:

Surface Water Supply Index

The SWSI is suitable for the calculation of hydrological droughts, because incorporates climatologic and hydrological characteristics into a single index value, which has the same classification as the Palmer indices (Shafer & Dezman, 1982). The calculation of exceedance probabilities used in the SWSI, are based on historical data. [11]

Palmer Hydrological Drought Index

The PHDI is a method to calculate hydrological droughts based on precipitation and evaporation (Heim, 2002; Weber & Nkemdirim, 1998). The PHDI depends more on the value of the previous time step than the PDSI. This makes it more suitable for the calculation of hydrological droughts since they often have more memory. [12]

Groundwater Resource Index

This index, developed by Mendicino et al. (2008), was tested in Calabria, Italy. The GRI is based on a normal distribution of the simulated groundwater storage in at a site. Since the GRI is a very new drought indicator, the performance of the GRI has only been tested by Mendicino et al. (2008) with 40-years of simulated data. The simulated data were generated by a hydrological model which used: precipitation, air temperature, and air pressure data as driving force. [13]

SPI (Standard Precipitation Index)

SPI is a probability index, considered only precipitation for any given time scales, which was developed for monitoring and assessing drought for any rainfall station with historic data. [6] The SPI was developed by McKee et al (1993). It was designed to quantify the precipitation deficit for multiple time scales.

In order to calculate the SPI, a probability density function that adequately describes the precipitation data must be determined. The gamma distribution function was selected to fit the precipitation data from each station. The SPI is a *z*-score and represents an event departure from the mean, expressed in standard deviation units. [6] The SPI is a normalized index in time and space. SPI values can be categorized according to classes. The departure from the mean is a probability indication of the severity of the wetness or drought that can be used for risk assessment. [9] The time series of the SPI can be used for drought monitoring by setting application-specific thresholds of the SPI for defining drought beginning and ending times. Accumulated values of the SPI can be used to analyze drought severity. The SPI is usually calculated for monthly periods. The meteorological station(s) to be analyzed should be chosen to be representative of the area being assessed for drought risk. The quality of the monthly data should be checked for reliability and suitability prior to its use for an SPI analysis. [5] Long records are desirable because SPI is a statistical approach and long records provide more reliable statistics.

Over the years, many drought indices were developed and used by meteorologists and climatologists around the world. However, an index needed to be simple, easy to calculate and statistically relevant and meaningful. Moreover, the understanding that a deficit of precipitation has different impacts on groundwater, reservoir storage, soil moisture and stream flow American scientists McKee, Doesken and Kleist developed the Standardized Precipitation Index (SPI) in 1993. It is just as effective in analyzing wet periods/cycles as it is in analyzing dry periods/cycles. At least 20-30 years of monthly value is needed and with 50-60 years (or more) being optimal and preferred outputs (Guttman, 1994).

METHODOLOGY

The principal idea of selecting each of the stations, was to cover all 4 regional areas of the island and to better understand the behavior A selection of 7 stations throughout Puerto Rico where selected to analyze the data and to see the behavior of drought in each different zones. The selected stations where: Ceiba; Roosevelt Roads, Dos Bocas; Utuado, Guayama, Magueyes Island, Maricao, Ponce and San Juan International Airport. After the selecting the stations to be evaluated, the monthly precipitation for all the areas where requested to the NOAA agencies. [5] After receiving the monthly data it was set up and put in an input file containing precipitation data from the selected study area. All input files must follow by a 3-column format which contains: Year, Month, and Monthly Precipitation Value. In this study, the SPI_SL_6 program developed by the National Drought Mitigation Centre, University of Nebraska-Lincoln has been used to compute time series of drought indices (SPI) for the selected station and for each month of the year at different time scales.

The SPI calculation for any location is based on the long-term precipitation record for a desired period. This long-term record is fitted to a probability distribution, which is then transformed into a normal distribution so that the mean SPI for the location and desired period is zero (Edwards and McKee, 1997) [6]. Positive SPI values indicate greater than median precipitation and negative values indicate less than median precipitation. Because the SPI is normalized, wetter and drier climates can be represented in the same way; thus, wet periods can also be monitored using the SPI.

McKee and others (1993) used the classification system shown in the SPI value table below (Table 1) [5] to define drought intensities resulting from the SPI. They also defined the criteria for a drought event for any of the timescales. A drought event occurs any time the SPI is continuously negative and reaches an intensity of -1.0 or less. The event ends when the SPI becomes positive. Each drought event, therefore, has a duration defined by its beginning and end, and an intensity for each month that the event continues. The positive sum of the SPI for all the months within a drought event can be termed the drought's "magnitude".

Table 1
SPI Values [5]

2.0 +	Extremely wet
1.5 to 1.99	Very wet
1.0 to 1.49	Moderately Wet
-.99 to .99	Near Normal
-1.0 to -1.49	Moderately Dry
-1.5 to -1.99	Severely Dry
-2 and less	Extremely Dry

Different SPI timescales to be computed 1-month, 3-month, 6-month, 9-month, 12-month, 24 -months and 36- months SPIs. Positive and negative SPI values indicate wet and dry conditions respectively. A drought event starts when SPI value reaches -1.0 and ends when SPI becomes positive again.

Table 2
Probability of Recurrence

Table 2. Probability of recurrence

SPI	Category	Number of times in 100 years	Severity of event
0 to -0.99	Mild dryness	33	1 in 3 yrs.
-1.00 to -1.49	Moderate dryness	10	1 in 10 yrs.
-1.5 to -1.99	Severe dryness	5	1 in 20 yrs.
< -2.0	Extreme dryness	2.5	1 in 50 yrs.

Analysis of SPI

For the analysis of the program SPI, it will be divided into sections explaining the significance of each method for the best results.

1-month SPI

A 1-month SPI map is very similar to a map displaying the percentage of normal precipitation for a 30-day period. In fact, the derived SPI is a more accurate representation of monthly precipitation because the distribution has been normalized. For example, a 1-month SPI at the end of November compares the 1-month precipitation total for November in that particular year with the November precipitation totals of all the years on record. Because the 1-month SPI reflects short-term conditions, its application can be related closely to meteorological types of drought along with short-term soil moisture and crop stress, especially during the growing season. The 1-month SPI may approximate conditions represented by the Crop Moisture Index, which is part of the Palmer Drought Severity Index suite of indices. [5]

3-month SPI

The 3-month SPI provides a comparison of the precipitation over a specific 3-month period with the precipitation totals from the same 3-month period for all the years included in the historical record. In other words, a 3-month SPI at the end of February compares the December–January– February precipitation total in that particular year with the December–February precipitation totals of all the years on record for that location. Each year data is added, another year is added to the period of record, and thus the values from all years are used again. The values can and will change as the current year is compared historically and statistically to all prior years in the record of observation. [5]

6-month SPI

The 6-month SPI compares the precipitation for that period with the same 6-month period over the historical record. For example, a 6-month SPI at the end of September compares the precipitation total for the April–September period with all the past totals for that same period.

The 6-month SPI indicates seasonal to medium-term trends in precipitation and is still considered to be more sensitive to conditions at this scale than the Palmer Index. A 6-month SPI can be very effective in showing the precipitation over distinct seasons. For example, a 6-month SPI at the end of March would give a very good indication of the amount of precipitation that has fallen during the very important wet season period from October through March for certain Mediterranean locales. Information from a 6-month SPI may also begin to be associated with anomalous streamflow's and reservoir levels, depending on the region and time of year. [5]

9-month SPI

The 9-month SPI provides an indication of inter-seasonal precipitation patterns over a medium timescale duration. Droughts usually take a season or more to develop. SPI values below -1.5 for these timescales are usually a good indication that dryness is having a significant impact on agriculture and may be affecting other sectors as well. Some regions may find that the pattern displayed by the map of the Palmer Index is closely related the 9-month SPI maps. For other areas, the Palmer Index is more closely related to the 12-month SPI. This time period begins to bridge a short-term seasonal drought to those longer-term droughts that may become hydrological, or multi-year, in nature. [5]

12-month or more SPI

The SPI at these timescales reflects long-term precipitation patterns. A 12-month SPI is a comparison of the precipitation for 12 consecutive months with that recorded in the same 12 consecutive months in all previous years of available data. Because these timescales are the cumulative result of shorter periods that may be above or below normal, the longer SPIs tend to gravitate toward zero unless a distinctive wet or dry trend is taking place. SPIs of these timescales are usually tied to stream flows, reservoir levels, and even groundwater levels at longer timescales. In some locations, the 12-month SPI is most closely related with the Palmer Index, and the two indices can reflect similar conditions. [5]

GMDH SHELL – Time Series Forecast

After recollecting all the data and having it analyzed by the SPI program, it was determined to find a way to make predictions on the next years. This determination was presented to make the data obtained from the SPI program more useful for governmental agencies to make conscience in the society. With making the necessary steps to create conscience about drought, people tend to make more awareness about the use of drinking water. For this case, it can determined how much time it will need to happen high or low peaks of precipitations and droughts so it can be taken by an average of years to make future probability predictions. The results reflect that it takes, an average of 4 years to happen a high level in precipitation and 6 years to happen a severe drought. An important note of this method, is that each case is different and greatly will be affected by the different types of regions.

The other method used in the process is to take the data analyzed with the SPI program and inserted in a time series forecasting model to make future predictions. The GMDH Shell is a time series forecasting model on which consist of making predictions of future events with the data that it is inserted on the program. GMDH Shell can make predictions from 1 month to 72 months average on which it has to be put in perspective that the longer the predictions are made, the results are less accurate.

The data obtained of the 12 month SPI evaluated earlier, was then inserted on the GMDH Shell program to make the forecast in this case with the same 12 month SPI method but for 60 months taken from December 2014 to December 2019. The stations used for this study was San Juan, Ponce, Dos Bocas – Utuado and Ceiba. Overall the model used automatic forecasting using the data inserted by the user, made the forecasting equations automatically and finally executed the prediction with SPI values for the upcoming 5 years. The model works by doing a model fit from the data imputed and finally making the predictions. The model has a period of warming on which the program itself makes the model fitting of all the data to make the predictions more certain and accurate in the time period stabilized by the user. When the model makes a certain model fit of the data inserted, the results will be more accurate as a result.

ANALYSIS OF DATA

Seven stations throughout Puerto Rico were selected and evaluated using the program SPI to better understand the behavior of periods of low and high precipitations. The stations selected were with the idea to cover all the important zones of the island; North, East, South and West. The results for most of the stations showed different behaviors of precipitations. Curiously all of the areas studied had something in common, the events of drought were presented on different time periods but not present all at the same time. This variation in time periods of drought can be explained by the changing of the different that were studied. One case for example can be, the big drought of 1994 which appears in the Dos Bocas station as an all-time negative value of precipitation but in San Juan Airport station, it wasn’t reflected the same event in the station. It has to be very important to acknowledge that an event of drought starts when the values of SPI in -1 until it reaches a positive value.

Other analysis of the program that can be used only in past events of drought but also it can used to measure and analyze high events of precipitation. SPI shows on how values of high precipitation changes throughout the different stations around Puerto Rico. With high values of precipitation presented in the results of the analysis of the SPI, it can be assumed that are events of high precipitations such as: tropical depressions, tropical storms or even hurricanes. This conclusion was reached when values of SPI turned positive in a short period of time. This sudden change in positive precipitations reflected by high amounts of rain appear to pass by in a limited time period, making it similar to such nature events more like storms and hurricanes.

On the other hand, with the results obtained from the program, it can be used to find a relationship on the events of the El Niño and La Niña. This events are more normal to be present in the Equatorial Pacific or in the western hemisphere where this was first discovered in 1795. After analyzing the figure 1 of the El Niño and La Niña with the results obtained of the stations analyzed in the study, it was determined that it didn't have a direct pattern of behavior from each region (Pacific and Atlantic). With this analysis done, it can be ruled out that a possibility to have either the Niña or El Niño on full effect in the Equatorial Pacific, can't affect directly the region of the Atlantic Ocean or in this case the region of the Caribbean.

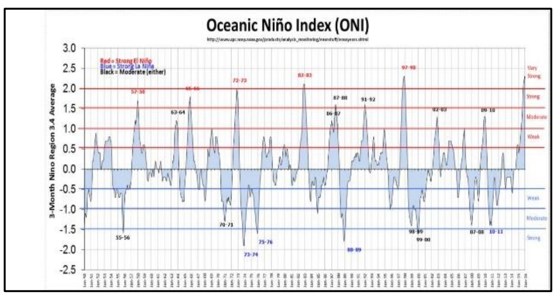

Figure 1
Oceanic Niño Index (ONI) [14]

ANALYSIS OF RESULTS

In the analysis of results, it will be made separately by regions rather than analyzing all the data as one. All of the data used to evaluate were 12 month SPI on which it is used to monitor severe droughts affecting ground water, rivers, reserves, etc.

San Juan - International Airport Station

Results of San Juan International Airport Station, reflects different events of precipitations such as: Tropical Storm Claudette, Tropical Storm Gert, Hurricane Hugo, Hurricane Hortense and Hurricane Georges. For the values of low precipitations ever recorded were the years 1972 and 1974 as the worst drought ever recorded in history, second by 1983 and third to 1992. The data showed in the graphic indicates that the worst drought in San Juan didn't happened in important years registered by the media. (Years 1984, 1994 or 2004). The other data reflected in the analysis was the year 2010 with the highest year with the most precipitation in history ever registered. Refer to figure 2 for more information.

Ceiba – Roosevelt Roads Base Station

With comparison of the Station of San Juan International Airport, it didn't reflect the same events of drought. The data showed reflects high levels of precipitation but not on import dates were hurricanes appeared to pass in the area. Some of the years with big precipitations were 1979, 1988, 2006 and 2012. Drought events on the other hand didn't be such drastic as in San Juan. With the years of 1973 and 2004, Ceiba had the worst years of drought. For Ceiba son of the years it had a normal behavior between periods of lows and high precipitations levels. Refer to figure 3 for more information.

Utuado - Dos Bocas Station

For the case of Dos Bocas Station, the analysis of the area reflected and interesting pattern on which high periods of precipitations were contrasted with low values indicating drought. For the events of drought it reflects only two events of severe drought in 40 years on which where, the year 1994 and the year 1998. It is important to notice that in this area it reflected the most severe year in one of the years that was registered in Puerto Rico, with the worst drought which was the year 1994. In comparison to other stations, this reflects that this area was the most affect by the drought. Some of the years with high levels of precipitations are: 1971,1982,1999,2005 and 2010. Refer to figure 4 for more information.

Guayama Station

This station of all the others is one very distinctive. This area can be shown to be affected by drought most part of the time in the 40 years analyzed. Guayama Station by been on the south east corner of Puerto Rico, it has been objected to a lot of wild forest fires and land fires because of the high temperatures registered. With this said, the results of the SPI analysis reflects that the values of drought appear more often than other stations because of the problematic this area has. High events of precipitations appear but not as much. The years of more noticeable drought are: 1977, 1980, 1987, 1990, and 1993. High values of precipitations appear in the years: 1971, 1980, 2004, 2008, and 2010. Refer to figure 5 for more information.

Magueyes Island Station

Magueyes Island appear not to be affected as much by periods of drought like it happened on the Guayama Station presented earlier. The station of Magueyes has the same behavior as Dos Bocas Station, making it a station with similar behaviors of dry periods and periods with high precipitation. For the years with the worst drought were: 1992, 1998 and 2003 as the second worst drought. For the values of high precipitations it shows the years: 1976, 1979, 1988 and 1998 with the most precipitations values in 40 years analyzed. One noticeable event reflected with the high precipitations was produced by the hurricane Georges in the year 1998. Refer to figure 6 for more information.

Maricao Station

The Maricao Station had some of the same problems as the Guayama Stations because of its southern location. On the analysis made, it can be showed more constant low periods of precipitation (drought) more high levels (precipitation) over the time period of 40 years.

For the years with noticeable severe droughts are: 1992, 1994, 1998 and 2007. The years presented with high precipitation levels are: 1976 and 2000. Refer to figure 7 for more information.

Ponce Station

Ponce station, has noticeable changes through the 40 years of analyzed, on which it reflects an active behavior making it a region with variable periods of high and low precipitation levels. Not at less, this area is considered to be one of the hottest places in Puerto Rico with a lot of high temperatures registered throughout the year. Curiously, the analysis made by the SPI program it reflects not only a variable of variance but not the normal behavior you would expect from this area. For the years of high precipitation levels are: 1971, 1979, 1985, and 2004. With this registered, it can be contrasted to the years of severe drought which are: 1973, 1981, and 1994. The year 1994 was registered for the worst drought ever recorded. Some of the high precipitations events presented in the graphic can be assumed to be: Hurricane David, Hurricane Hortense, and Hurricane George. Other precipitations peaks can be subjected to natural events with a lot of rain for instance, tropical depression or storms. Refer to figure 8 for more information.

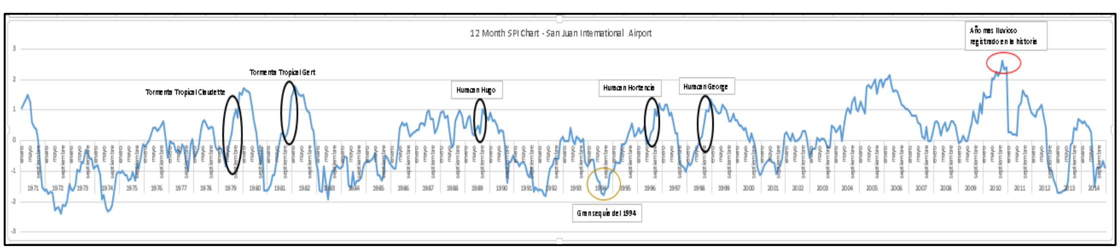

Figure 2
San Juan - International Airport Station (12 month SPI)

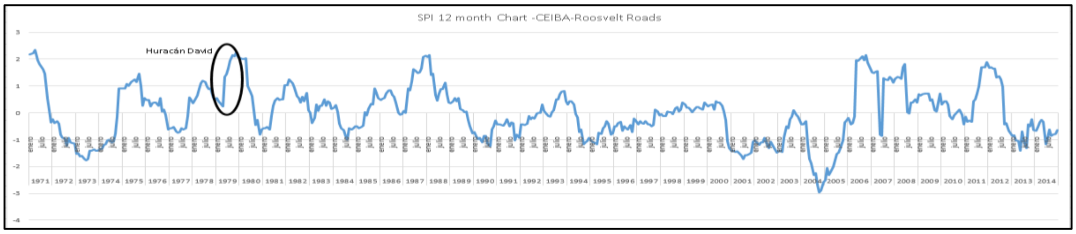

Figure 3
Ceiba – Roosevelt Roads Base Station (12 month SPI)

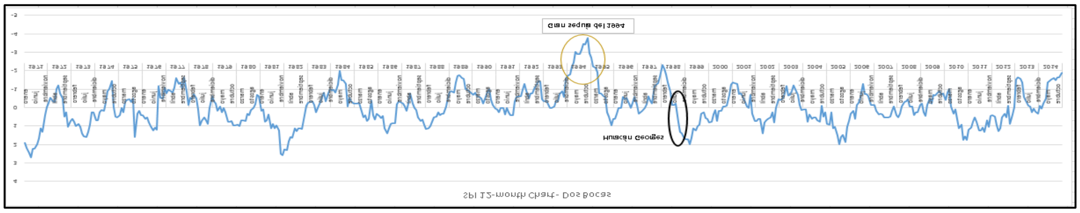

Figure 4
Utuado- Dos Bocas Station (12 month SPI)

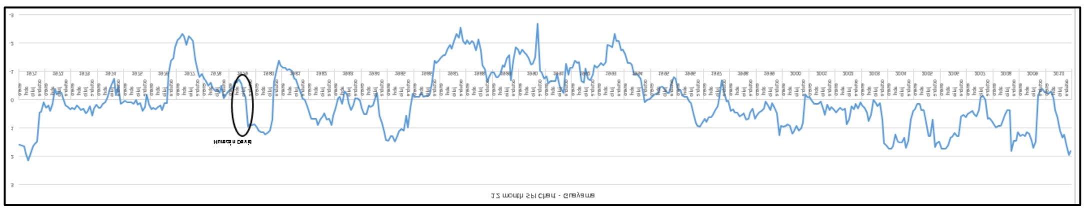

Figure 5
Guayama Station (12 month SPI)

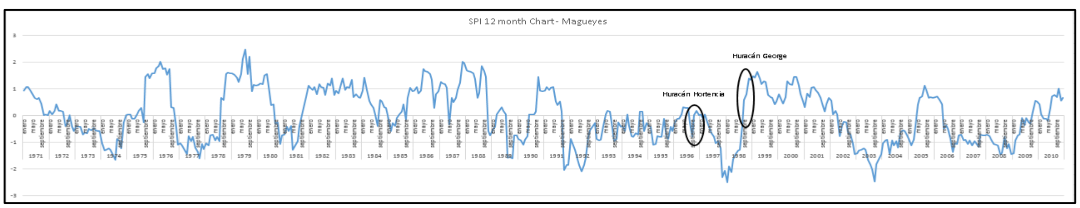

Figure 6
Magueyes Island- Station (12 month SPI)

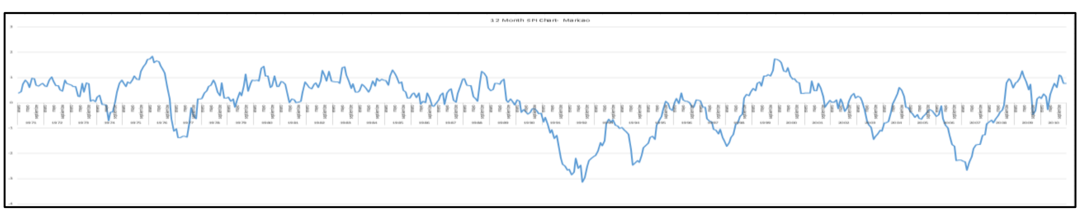

Figure 7
Maricao Station (12 month SPI)

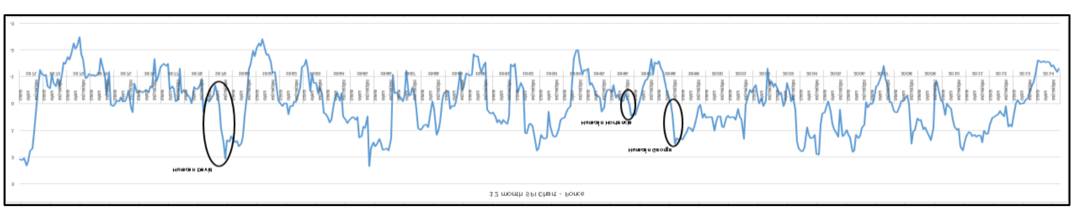

Figure 8
Ponce Station (12 month SPI)

After analyzing all the data executed on the SPI program, it was made the automatic predictions for all 4 stations throughout Puerto Rico. The main idea for running of the program was to determine that will happen in the next 60 months of data.

Results of the GMDH Shell program run reflected that in a period of 5 years all of the stations had a tendency of high precipitations levels rather than low levels of precipitations, indicating large presence of quantity for precipitation rather than periods of low levels of precipitations. With this determination it makes a big difference in the game of predictions to better understand how the next 5 years are going to be reacting. The use of the data from the SPI programs makes a huge difference for making prediction models on which it can be used to make future predictions with values of great reputation.

Up next are the graphs and results of the predictions models using 12 month SPI program values to predict drought in 4 stations around Puerto Rico.

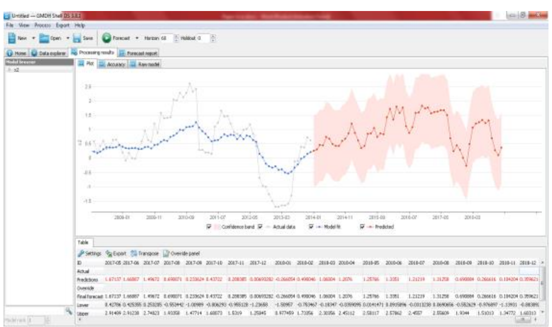

Figure 9
San Juan - Forecast

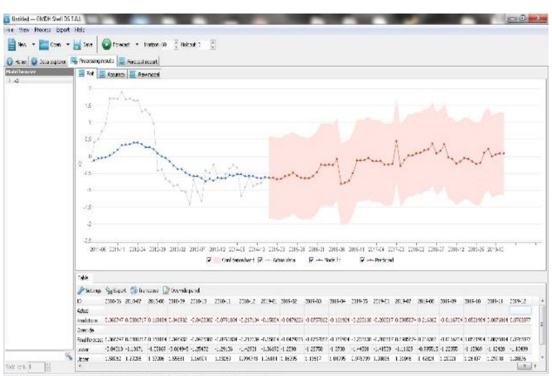

Figure 10
Ceiba Roosvelt Roads Base - Forecast

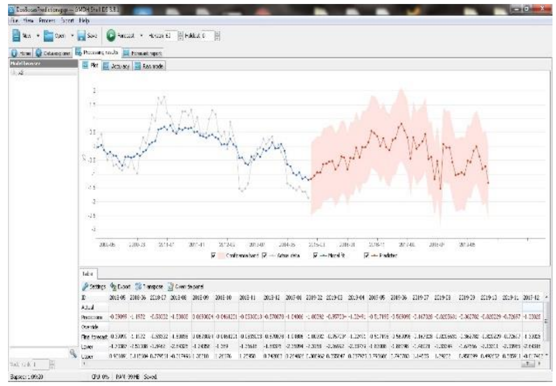

Figure 11
Dos Bocas Utuado - Forecast

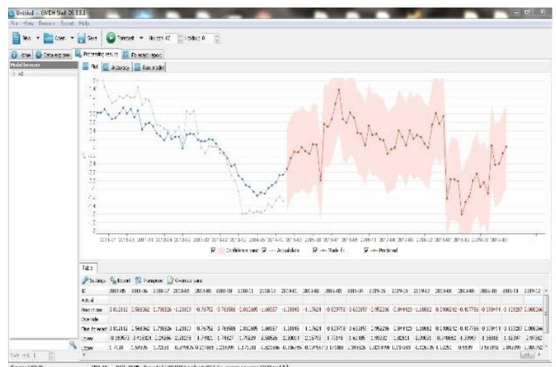

Figure 12
Ponce – Forecast

CONCLUSION

The use of the Standard Precipitation Model (SPI) was been a useful tool to see the behavior of past events of precipitations (high or low) in the Island of Puerto Rico. With this program, the user can make unlimited types of analysis from the data obtained from past events and to make future predictions for years to come. The SPI program doesn't stop there, it can also be used for making time series forecasting that help many people to prepare for future events and to make awareness of how to make use of the program. The use of drinking water in the island of Puerto Rico has been badly used because of the lack of conscience of the people. By implementing this tools, making analysis of the past events and making predictions takes us one step closer to making the people of Puerto Rico more conscience of the importance of drinking water and to make a more efficient use of it.

The use of the SPI program and the GMDH Shell makes the perfect combinations to better understand the ever changing climate that we are living in because of the variation of region locations. Having these predictions made with combinations of the programs, changes the game on predicting future events and makes it a resourceful method for making future predictions for events of drought. With this tool, agencies can make better plans and judgement on which alternatives to take for the preparedness of drought seasons.

When people are better informed and conscience has been made in their lives, people take care more of things that natures provides. If this been said one important quote that need to take importance in our life is by Leonardo Da Vinci: "Water is the driver of nature".

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