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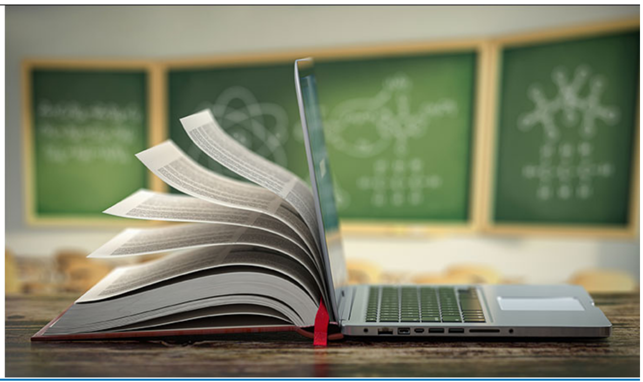

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Effects of Climate Change on the Surface Waters of the Santa River, La Rinconada - Ancash – Peru

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Abstract. The effect of climate change on the surface waters of the Santa River, the town center la Rinconada, Ancash, Peru, was assessed. Climate change was modeled between 2006 - 2015, through temperature, precipitation, and historical evapotranspiration *versus* surface waters based on water availability, and the best regression equations were selected. A validated survey of users of the Rinconada Irrigation Commission (CRR) was also taken. The best equation was exponential type for surface water and average precipitation. In contrast, for surface water and climate change the most appropriate was multiple linear regression. In relation to the survey, 83.33% strongly agree that they are concerned about climate change, and 81.37% agree that they are fully prepared for climate change caused by high temperatures. 27.5 % strongly disagree that the amount of water available in the canals has decreased because of climate change. It is concluded that it is possible to predict water availability in the face of the presence of climate change by applying regression users equations, and that there is concern of CRR users, in the face of the presence of climate change.

1. Introduction

Global water demand is expected to continue to increase at a similar rate until 2050, an increase of 20 to 30% above the current level of water use. More than 2,000 million people live in countries suffering from severe water scarcity, and approximately 4,000 million people suffer from severe water scarcity for at least one-month a year. [1]. The current state of freshwater resources globally is of great concern. This situation in the world caught up in a water crisis attracts both producers and users to develop simulation models, generating future projections, in the field of sustainable water management [2]. This deficit in irrigation water generated by action of climate change is the least favorable scenario, which will be offset by an increase in the proportion of regenerated resources along with the desalination [3].

Perez [4] reverse that precipitation will experience decreases of 15% in the less negative scenarios, and that evapotranspiration (ETO) will show a widespread ascent of more than 5% compared to current records. It also mentions that there is a reduction in the water availability of the basins analyzed through the hydrological model, providing significant values, with negative variation rates that between 30 and 50 % for the most realistic scenarios. The losses in water resources due to climate change are evident, with a great impact on the Mediterranean region that is most vulnerable due to its current water scarcity. In the Maghreb countries (Algeria, Morocco and Tunisia) there is a worrying situation regarding the availability of water manifested by drought that accentuates the phenomenon of desertification, the increase in soil salinity and the decrease in piezometric levels of the [5]. Global climate change will affect the entire hydrological cycle; therefore, adaptation measures should consider the possible effects on the various components of the cycle [6].

The author reviews the relationship between climate change and water resources, the response of circulating water to climate change. And it raises study problems and raises the development trend, which includes perfecting the distributed hydrological model, improving the accuracy of climate models and hydrological models, and developing two-way coupling techniques for climate models and hydrological models [7]. Runoff is projected to increase by 10 to 40% by mid-century at higher latitudes and in some humid tropical areas, including populated areas in East and Southeast Asia due to increased rainfall and lower rates of evapotranspiration. In addition, it is projected to decrease by between 10 and 30% in some dry regions at dry mid- and tropic latitudes, due to decreased rainfall and higher rates of evapotranspiration. At the regional level, a large increase in demand for irrigation water is projected because of climate change. Studies in recent years have shown significant vulnerabilities in regional water resources to changes in both temperature and precipitation patterns [8].

In this research, the impact on the environment and sustainable development was assessed in the town center of Rinconada. And it aims to value the effects of climate change on the surface waters of the Santa River, a town center of Rinconada - in the district of Santa, Ancash, Perú.

2. Materiales and methods

The population was made up of 267 users of the Rinconada Irrigation Commission (CRR) in the district of Santa, Ancash, Peru, which is dedicated to the agricultural production of crops installed on their agricultural lands, and their connection with the lateral diversion canals; that allow the use of surface waters. The sample was chosen based on convenient statistical methods. A questionnaire with 18 questions was developed in a survey. This survey was applied in January 2020, with the support of three people who belonged to the CRR. The relationship between the two variables to be investigated was consulted: Climate change, and surface water. Cronbach's alpha was used for reliability. For the validity of the instruments, the judgment of five experts was used based on five criteria: Congruence of the item, breadth of content, writing of the item, clarity-precision, and finally relevance.

To carry out the descriptive and inferential calculations, the multiple linear regression equations of the SPSS 25.0 software were used. The Curve expert professional software was employed in which it was used after selecting for the calculation among 64 different equations, and only the best equations were selected and the Hidroesta-2 software was also used.

To develop this research, the Pisco Senamhi database [9] was chosen at the same point, where the Chimbote weather station is located. The information I analyzed was for precipitation: Maximum, minimum, and average, temperature: Maximum, minimum and average, information that was validated with the data of the Chimbote Meteorological station of the Directorate of Hydrography and Navigation of the Navy (DHN). This information was related to the consumption of surface water on an annual basis to serve the crops installed in the Rinconada area, provided to us by the Santa User Board.

3. Results

According to the analysis of the surveys of the eight questionnaire questions, and based on the two variables, the following was obtained in Table 1.

Table 1. Questionnaire responses of the relationship between climate change variable *versus* surface water.

No.	Questions	1: Strongly disagree/%		2: Disagree/%		3: Neither agree nor disagree/%		4: Agree/%		5: Strongly agree/%	
1	*He is worried about climate change.	1	1	0	0	16	15.7	0	0	85	83.33
2	*You are prepared for climate change, caused by low temperatures.	8	7.8	0	0	1	1	73	71.57	20	19.61
	*It is prepared for climate change, produced by high temperatures.	7	6.9	0	0	3	2.9	31	30.39	61	59.8
4	*It is prepared for climate change, caused by mild rains.	8	7.8	0	0	1	1	83	81.37	10	9.8
5	*It is prepared for climate change, caused by heavy rains.	6	5.9	4	4	3	2.9	78	76.47	11	10.78
6	*He struggled in water supply, in the canals because of climate change.	16	15.7	1	1	2	2	73	71.57	10	9.8
7	*The amount of water available in h-channels has decreased because of climate change.	28	27.5	1	1	0	0	68	66.67	5	4.9
8	*The amount of water available has increased due to climate change.	19	18.6	3	3	0	0	77	75.49	3	2.94

Table 1 shows that the largest number of people fully agrees, and show concern about climate change, and fewer people who are not yet aware of the consequences of climate change.

Table 2. Alfa de cronbach**.**

Cronbach Alpha	For the climate change dimension vs Surface waters
K (number of items)	8
Vi (Variance of each item)	4.88
Vt (Total Variance)	12.79
	0.73

From Table 2, Cronbach table, for the dimension of climate change vs surface water, you get 0.73, which according to the reliability criteria it is acceptable.

Table 3. Regression equations that assess the relationship between climate change vs surface water variables. Tmin= Minimum temperature. Tmax = Maximum temperature. Tprom = Average temperature. Pmin = Minimal precipitation. Pmax = Maximum precipitation. Prom = Average precipitation.

Relationship	Equation	Type	Determination coefficient R2	Program
Surface water (y) vs Average precipitation (x)	y =1.8372129*0.8024095x	Exponential	0.17	Hydroesta 2
	y =21.9025398*X 0.2148417	Power	0.32	Hydroesta 2
	y = -0.119*0.083x	Exponential	0.33	SPSS
		DR-Multistage-3(Multi-stage 3)	0.25	Curve expert professional
	y = (1.73978+1.8110*x)/ (1+8.060228*x+4.796413*x2)	Rational model	0.25	Curve expert professional
Surface water (y) vs Tmin, Tmax, Tprom, Pmin, Pmax, Pprom, evapo	y =-4,091-0.30*Tmin-1.001*Tmax +1,466*Tprom+4.867*Pmin-0.155*Pmax-4,037*Pprom-0.37*Evapo	Linear	0.54	Spss
	y = -208.208-0.643*Tmin 1.632*Tmax+33.594*Tprom+29.497*Pmin+0.864*Pmax-3.978*Pprom-5.291*Evapo	Linear	0.74	Spss

From Table 3, with the SPSS, we achieved the better determination coefficient R^2, between surface water *vs* climate change variables, as well as with Hydroesta 2 is the one that gives us the lowest correlation: 0.17, between surface water versus average precipitation.

Table 4. Annual assessment of the Ratio of climate change variables and surface water. Tmin= Minimum temperature. Tmax = Maximum temperature. Tprom = Average temperature. Pmin = Minimal precipitation. Pmax = Maximum precipitation. Prom = Average precipitation. MM = million-meter cube.

Year	Tmin	Tmax	Tprom	Pmin	Pmax	Pprom	Surface Water (MMC)
2006	7.61	30.70	21.52	0.1	1.5	0.5	19.19
2007	8.22	30.78	20.74	0.0	0.8	0.3	12.32
2008	12.04	30.69	20.78	0.0	2.0	0.6	21.48
2009	7.96	30.28	21.39	0.0	11.4	1.4	25.73
2010	8.90	31.90	21.42	0.1	3.1	0.6	15.48
2011	7.25	30.48	20.68	0.0	1.9	0.5	19.99
2012	12.59	31.49	21.66	0.0	1.2	0.4	20.45
2013	12.22	30.93	21.18	0.0	11.8	2.0	21.20
2014	13.26	30.51	21.72	0.0	1.8	0.5	22.91
2015	13.41	30.97	22.52	0.0	3.7	0.7	23.81

From Table 4, in 2015, the highest annual water consumption of 23.81 MMC was carried out, and the minimum in 2007, 12.32 MMC, as well as the maximum was presented in 2010 with 31.90°C and the minimum in 2006 of 7.61°C. About precipitation, the maximum value of 11.8 mm was obtained in 2013 and the minimum between the years, 2007 to 2015.

4. Discussion

From the survey of farmers of rinconada's irrigators commission, based on the questions it seeks to find, entre the relationship between climate change vs surface water *vs* variables, it was known that a large majority are concerned about climate change, and another similar group claimed that they are prepared for climate change in the presence of low temperatures, and in the face of climate change, caused by mild rains, and water scarcity, in the canals. However, in the indigenous communities of the World and in Mexico, there is the possibility of a perception of climatic alterations according to the interviewee's interaction with the local environment, since the inhabitants of the indigenous communities were the ones who associated the variations in the climate with concrete actions carried out by human beings in their region [10]. In addition to farmers' opinion, rainfall has been delayed in recent years, delaying the date of crop planting, and being affected by frost [10].

The calculation of the Cronbach alpha was carried out, for the 8 questions, which were applied to farmers of the Rinconada Irrigation Commission, obtaining an alpha Cronbach coefficient of 0.73, for the climate change dimension versus surface water. According to the research carried out, a high internal consistency was obtained since Cronbach's coefficient alpha reached 0.91, on the other hand, the correlations obtained indicate a good relationship and dependence between them, so we can say that this study has generated an instrument that valid of learning research skills, since the results presented confirm the high reliability, factorial validity, and content [11].

From the analysis in Table 4, it could be observed that in 2015 more water was used (23.81 MMC) and it is in November more water was consumed (2.38 MMC), for the installation of crops, in 2007 it was less than 12.32 MMC water was consumed, in March 1.24 MMC but in 2010 was obtained 31.90 °C, in February, and the lowest in 2006, 7.61°C, also with respect to precipitation the highest value (11.8 mm) was presented in 2013 in March. also, until 2010, in the north-central part of Quito have increased the average temperatures by 1.2 °C, which is accompanied by the minimum averages by 1.1 °C and finally the average maximum has been increased by 0.7°C, with respect to rainfall, have decreased in the order of approximately 7 mm of rainfall per month [10].

When the effects of climate change are evident, farmers intrinsically increase agronomic inputs (labor, irrigation, pesticides and others) to adapt to climate change, the farmer's adaptation measures themselves are very important to adapt to climate change, se should take into account that all we must do is keep markets free and remove trade barriers [12], according to [13]. the main results of this study show that climate change, specifically changes in temperature and precipitation, can have significant impacts on agricultural production in caribbean countries. The same author mentions that regional level by 2050, the expected impacts of climate change added for all crops represent a 7% drop from the average production for the period 1961-2014.

We can mention that it is only in times of water resource scarcity that planning begins. It should include the characteristics of each basin, the behaviors, and customs of the inhabitant of the basin, as well as all users involved in the use of the water resource, as well as the authors, mention, that, in the countries of South America, simulation models have been developed to assess the effects of climate change; however, these are not yet articulated with government plans or population needs [14].

5. Conclusions

An evaluation instrument was obtained for the conduct of a survey which was validated by the experts on the subject and statistically endorsed obtaining an alpha Cronbach coefficient of 0.73, for the variable ratio of this research.

There is great concern of the farmers of the Rinconada irrigators commission, in the face of climate change, because it is affecting the production of their installed crops, with the increase in temperature and the decrease in the amount of water available, but they feel prepared in the presence of low temperatures and decrease in rainfall in the upper part of the Santa River basin.

The presence of rainfall in the field of the Rinconada irrigator su commission, its influence on water availability is not relevant, however, its influence de of temperature and precipitation in the upper basin of the Santa River is relevant.

It is concluded that it is possible to predict water availability through climate change through various regression equations, and that there is concern of users CRR, in the face of the presence of climate change.

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