XVI World Water Congress
International Water Resources Association (IWRA)
Cancun, Quintana Roo. Mexico. 29 May- 3 June, 2017

EFFECTS OF CLIMATE CHANGE ON WATER AVAILABILITY IN A HYDROLOGICAL WATERSHED LOCATED IN AN ARID REGION IN THE NORTH CENTRAL PORTION IN MEXICO.

Humberto Silva-Hidalgo[1,2], Guadalupe Estrada Gutiérrez[1], Martha Lorena Calderón Fernández[1], María de Lourdes Villalba[1], Fernando Rafael Astorga Bustillos[1]
[1]Engineering Faculty, Autonomous University of Chihuahua; [2]hsilva@uach.mx

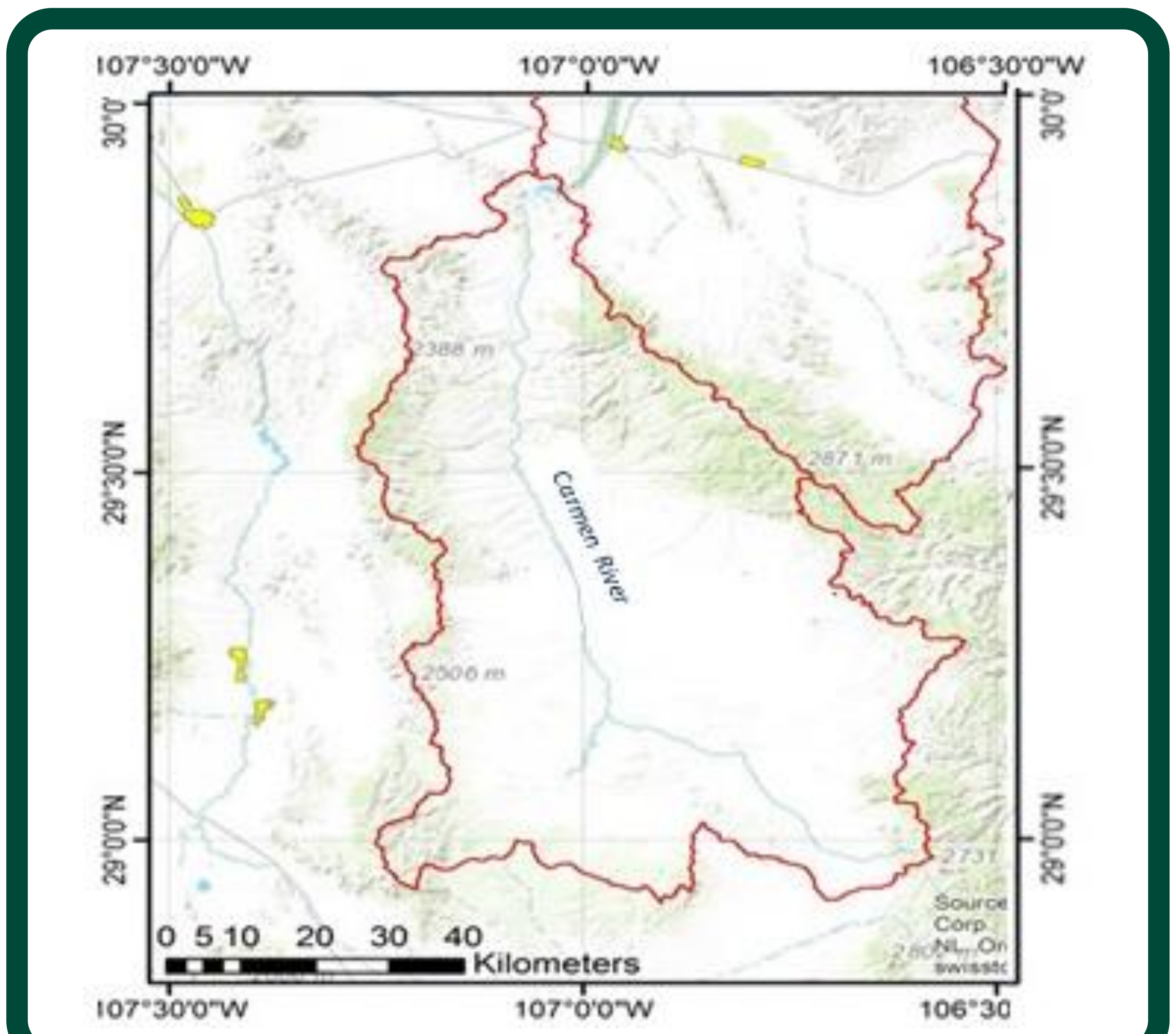
Acknowledgements: The authors wish to thank the Authorities of Engineering Faculty of the Autonomous University of Chihuahua, including the Secretariat of Research and postgraduate studies.

INTRODUCTION

Natural availability of water is very low in many latitudes of the planet that exhibit an arid or semiarid climate. However, phenomena such as climate change could affect these regions even more; so is very important to make an adequate management of water now, in order to minimize the adverse impacts in the near future. The northern part of Mexico, specifically the Hydrologic Region "Closed Basins of the North", in the State of Chihuahua, the Carmen river basin is located, water scarcity is its natural condition, so can be even deeply affected by changes in climate (CNA, 2013). At the outlet of the upper zone of the basin, "Las Lajas" Dam is located; from this dam, the Irrigation District 089 El Carmen, is supplied of water. Considering these statements,

OBJECTIVE

To assess the effects of changes in climate, throughout the analysis of rainfall patterns, and modifications observed in the land natural coverage, in terms of natural flows time series.



METHODOLOGY

The upper basin of the Carmen River is located in the north - central portion of the State of Chihuahua (Figure 1). This land area of just over 4,500 km^2, from inception to where the dam "Las Lajas" is located at the outlet (CNA, 1997). The predominant vegetation is natural pasture, Encino forest, Pine-Encino forest, Encino-Pine forest, temporal agriculture and urban area (INEGI, 2005; INEGI, 2015). There were changes in vegetation coverage from 1976 to 2000, mountainous area changed from primary forest to secondary forest. Some flatter areas changed from natural grassland to scrubland, induced grassland or agricultural area. Figure 2 shows the behavior of the annual precipitation, observing that from 1965 to 1992, the average was 414.7 mm and from this last year to 2012 decreased to 350.2 mm.

Determination of natural flows:

Natural flow (Cp) in gauged basins is determined through the following expression derived from the general mass conservation equation (SEMARNAT, 2015):

$$Cp = V2 + Exb + Ev - V1 + Ex - Im - R + \Delta V \quad (1)$$

Where:
V1= gauged volume entering from the upstream basin
V2= gauged volume exiting to the downstream basin
Exb= volume of surface water extracted or diverted in the basin
Ev= evaporation
Ex= exported volume
Im= imported volume
R= volume of return flows
ΔV= change in storage volume.

Runoff coefficient determination:

In order to determine the annual runoff coefficient (C_e), which expresses the rainfall-runoff ratio in a hydrological basin, the annual volume of natural runoff (V_e), as well as the volume of water precipitated in the basin (V_p), were used, according to the mathematical expression 3:

$$C_e = V_e / V_p \quad (2)$$

RESULTS AND DISCUSSION

Natural flow without considering irrigation returns (Ir).

Figure 3 shows the behavior of the annual natural runoff obtained for the period from 1965 to 2012, an average of 62.93 hm^3 was obtained. The behavior of natural flows shows a rise in the first nine years of the time series, and then a period of stability until 2012. The average evolution (red line) shows enough consistency compare to the average of the complete period of analysis (black discontinued line). Figure 4 shows the behavior of the annual runoff coefficient determined in basin. The trend of this variable is clearly to increase in the period analyzed. Changes in the behavior of the runoff coefficient in the long term could be due either to variations (increase or decrease) in the rainfall regime, or to changes in the vegetation cover. The rainfall regime could be affected for climate change phenomen. Changes in vegetation cover could be originated by: (1) the continuous and progressive decrease of precipitation, (2) lower groundwater levels in zones with phreatophyte vegetation, (3) human practices of over utilization of vegetation by cattle, or (4) removal of natural vegetation cover, for the development of agricultural areas.

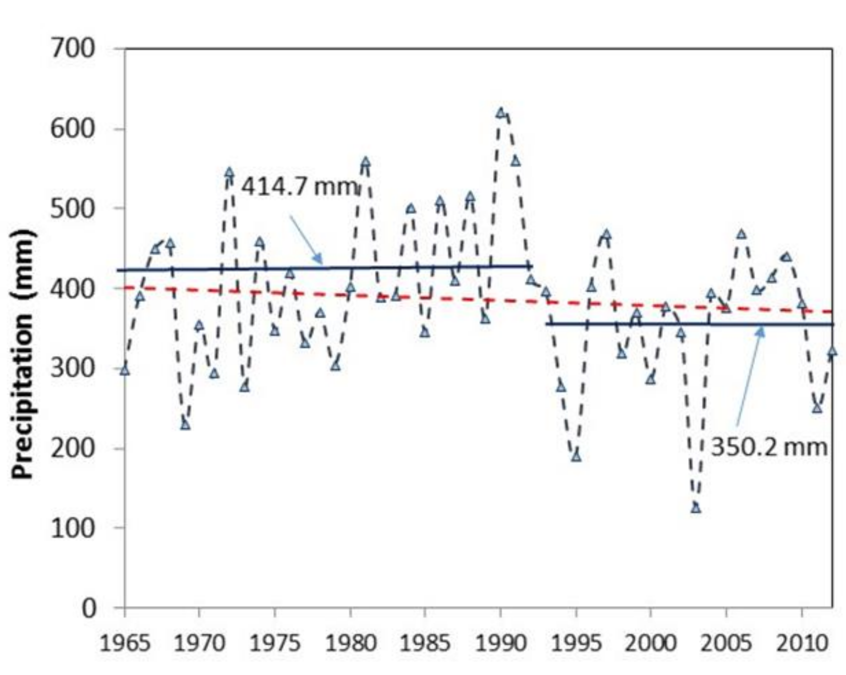


Figure 2. Annual Precipitation in the upper Carmen river basin from 1965 to year 2012.

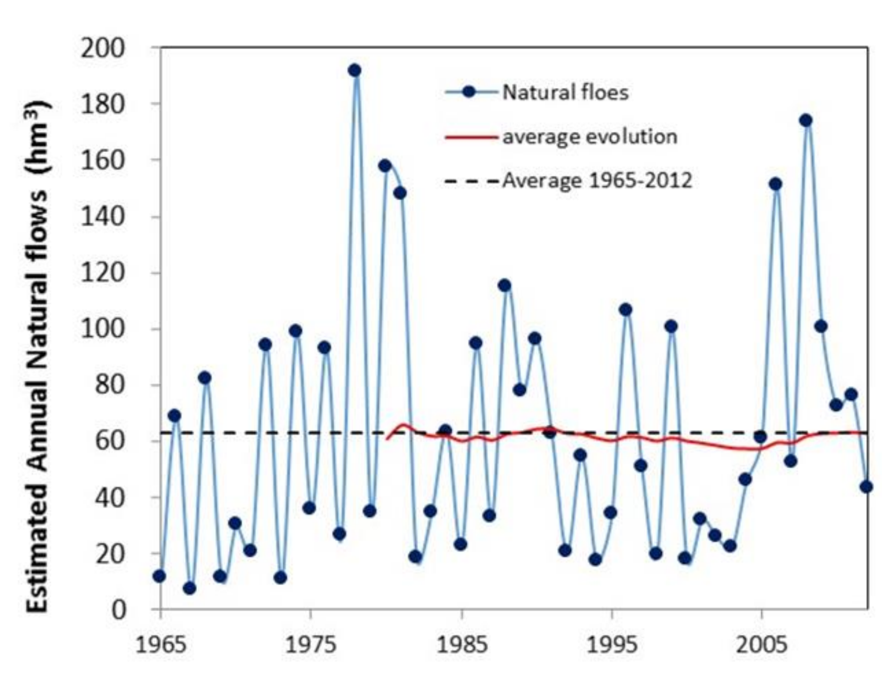


Figure 3. Annual natural flows determined for the period from 1968 to 2012 year.

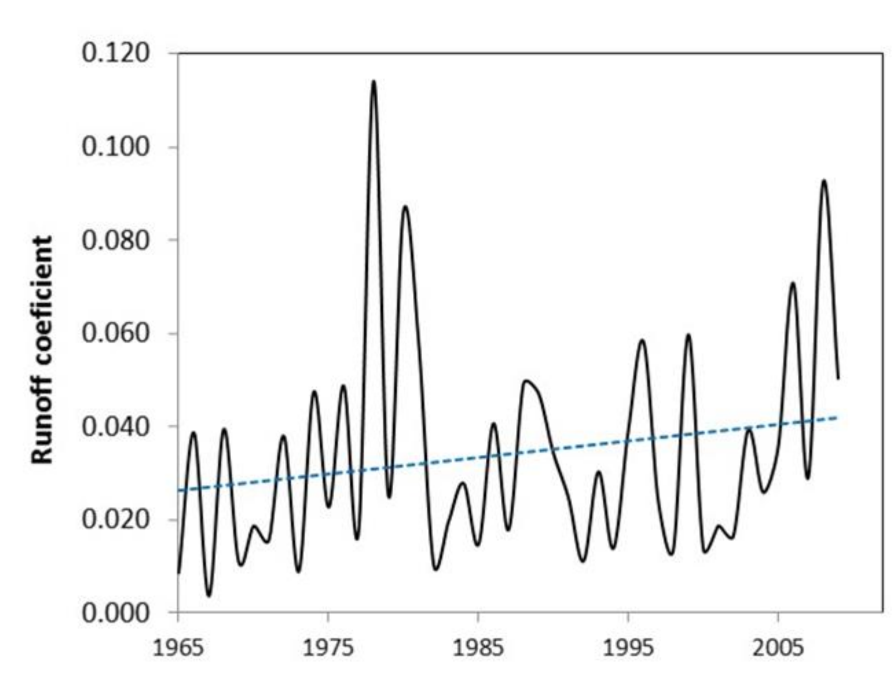


Figure 4. Behavior of runoff coefficient in the Carmen River upper basin

Natural flows using the "Alternative method".

Rainfall in the basin shows a significant decrease from 1993 to 2012 (Figure 2). As a result, natural flows could be expected to decrease, however, the average value of this variable tend to be preserved in the period from 1965 to 2012 year (Figure 3).

These finds an explanation when considering the changes held in the physical media. The vegetation cover in the upper basin of the Carmen River has been modified in various zones, causing an increase in the potential of generation of runoff, resulting in the increase in the runoff coefficient. This has allowed, despite the decrease in precipitation manifested itself in the last two decades of the analysis period, the average natural runoff has been preserved.

The runoff coefficient increase that apparently support the natural flows stability also represents a diminishing in the infiltration rate into the ground. This behavior alteration of the surface system could have negatives effects in terms of groundwater recharge in the future.

CONCLUSIONS

Tere were changes in the surface hydrologic system, in the precipitation regime and in the physical conditions. However, natural flows have preserved relatively stable, probably because the decrease in annual rainfall was compensate by the increase in the values of the annual runoff coefficient (caused by the physical changes in the basin, or changes in the rainfall intensity). Even natural flows does not shows notable changes as an annual average, the situation could be different in the future, especially if it is considered the modifications in rain patterns.

REFERENCES:

Comisión Nacional del Agua (CNA), (1997), Programa Hidráulico de Gran Visión del Estado de Chihuahua, Contrato: SGC-GRN-CHIH-96-82A, México. D. F.

Comisión Nacional del Agua (CNA), (2013) Acuerdo por el que se da a conocer los resultados del estudio de disponibilidad media anual de las aguas superficiales en la región hidrológica 34, denominada Cuencas Cerradas del Norte, Diario Oficial de la Federación, miércoles 31 de julio, (Primera Sección), México, D.F.

Instituto Nacional de Estadística Geografía e Informática (INEGI). (2005). Guía para la Interpretación de Cartografía: Uso Potencial del Suelo, Aguascalientes, Méx. http://www.inegi.org.mx/prod_serv/contenidos/espanol/bvinegi/ productos/geografia/publicaciones/guias-carto/potencial/ USOPOTSUELI.pdf. [Descargado en mayo de 2016]

Instituto Nacional de Estadística Geografía e Informática (INEGI). (2015). Conjunto de datos vectoriales uso de suelo y vegetación, escala 1:1,000,000. http://www.inegi.org.mx/geo/contenidos/recnat/default.aspx. [Descargado en mayo de 2016]

Secretaría de Medio Ambiente y Recursos Naturales (SEMARNAT), (2015), NOM-011-CNA-2015 Conservación del Recurso Agua - Que establece las especificaciones y el Método para determinar la disponibilidad media anual de las aguas nacionales,

Instituto Mexicano de Tecnología del Agua (IMTA) y Comisión Nacional del Agua (CNA), (2000), Banco nacional de Datos de Aguas Superficiales (BANDAS), CD, Volumen 7. Jiutepec, Mor.