Feasibility of sugarcane cultivation during the next five decades under RCP climate change scenarios. (Case study: Khuzestan province, Iran)

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Abstract:
The aim of this study is to investigate the feasibility of continuing cultivation of sugarcane in Khuzestan province, south west of Iran under climate change scenarios in the next five decades. The agriculture in region is mostly dependent on surface water but integrated utilization of ground and surface water is also considered. Water table in many parts of the province is high due to poor drainage management or geological structures. In poorly drained areas the water table might be as high as 10 meters. The elevation of the region is variable from 3700 m above m.s.l in northern part to below m.s.l in southern part close to Persian Gulf. The climate of the region is semi-arid and several major rivers of the country flow through this province hence it's a main hub for agriculture (by producing around 12000 tons, or18.9%, of agricultural products of Iran) and generating electricity power. Taking into account the region's climate and added value of sugar cane products, this crop has been widely cultivated in Khuzestan during the last decades which has faced major challenges especially drought and salinity. As the main part of the study, feasibility of continues cropping of sugarcane as affected by climate change and water table depth changes has been examined. Precipitation projections of 5th Coupled Model Intercomparison Project (CMIP5) under two scenarios over the study region and have been downscaled using Coordinated Regional Climate Downscaling Experiment (CORDEX) project data. The chosen scenarios for the current study are RCP4.5 and RCP 8.5 from the Representative Concentration Pathway Scenarios (RCPSs). The results showed the situation is likely to be unfavorable for producing sugarcane with no significant increase in region's rainfall. The projections of fifth assessment report (IPCC AR5) of Intergovernmental panel on climate change shows increase of frequency in extreme events of rainfall for this region while the amount would be almost as same as present. The assumptions used for the study were: 1-No change in existing dams capacity 2-No change in the genotype of the crop. Further studies using another scenarios are recommended for more security.

Keywords: Climate Change, water table depth, Iran, RCP Scenarios, sugarcane.

Introduction:
Water is a key element of agricultural production systems . Since the very beginning of ancient civilization and agricultural practices about 10,000 years ago, farmers have used irrigation water to increase crop yields by reducing their dependence on rainfall patterns, which led to a jump in the average crop production while decreasing the interannual variability (Fischer et al. 2007). The IPCC has reported that the expected global rise in temperature over the next century would probably be greater than observed in the last 10,000 years. As a direct consequence of warmer temperatures, the hydrologic cycle will undergo significant impact with accompanying changes in the rates of precipitation and evaporation (Allen et al. 2004). Averaged over the mid-latitude land areas of the Northern Hemisphere, precipitation has increased since 1901 (IPCC AR5 WGI, 2013). Optimum use of precipitation can be considered as one of the best options to decrease the amount of underground water extraction for agriculture in arid and semi-arid areas (Bannayan et al. 2011). The aim of the current study is to investigate the feasibility of continuing cultivation of sugarcane, in south west of Iran under climate change scenarios in the next five decades considering the changes in amount of precipitation.

Materials and Methods:
Khuzestan province covers an area of about 64,000 km^2 in southwest of Iran (Fig. 1). The province of Khuzestan can be basically divided into two regions, the rolling hills and mountainous regions north of the Ahvaz Ridge, and the plains and marsh lands to its south. The area is irrigated by the Karun, Karkheh, Jarrahi and Maroun rivers. Khuzestan has great potentials for agricultural development, which is almost unrivaled by the country's other provinces. Large and permanent rivers flow over the entire territory contributing to the fertility of the land. Karun, Iran's most effluent river, 850 kilometers long, flows into the Persian Gulf through this province. The agricultural potential of most of these rivers, however, and particularly in their lower reaches, is hampered by the fact that concentration of salt in this rivers is quite high, the amount of which increases as the rivers flow away from the source mountains and hills. In case of the Karun, a single tributary river, Rud-e Shur (Salty River) that flows into the Karun above Shushtar contributes most of the salt that the river carries. As such, the freshness of the Karun waters can be greatly enhanced if the Rud-e Shur could be diverted away from the Karun. The same applies to the Jarahi and Karkheh in their lower reaches. Only the Marun is exempt from this. The climate of Khuzestan is generally hot and occasionally humid, particularly in the south, while winters can be more cold and dry. Summertime temperatures routinely exceed 40 °C and in the winter it can drop below freezing, with occasional snowfall, all the way south to Ahvaz.

Figure 1: Geographical location of Khuzestan province in southwest of Iran

The study was performed using climatic data of 5 selected synoptic stations of the province. Table 1 shows the geographic and climatic information of stations that were used in this study.

Table 1: Geographic and climatic information of synoptic stations used in the study

Stations	Latitude (˚)	Longitude (˚)	Altitude (m)	Precipitation (mm.year^{-1})	Period
Abadan	30.22	48.15	6.6	155.5	1951-2005
Ahwaz	31.20	48.40	22.5	226.7	1957-2005
Dezful	32.24	48.23	143	401.7	1961-2005
Izeh	31.51	49.52	767	694.1	1993-2005
Shushtar	32.03	48.50	67	313.7	1994-2005

The crop chosen for the study is sugarcane ,largely cultivated in this province for producing sugar and other side products. The plant has a high thermal requirement that can be satisfied in warm climate of the region. Figure 2 shows the area harvested, production and yield of sugarcane in Iran from 1961 to 2013. Also table 2 shows the Iran's sugarcane production compared with other countries in south Asia. In recent decades, the ground water depth in main sites of sugarcane cultivation in Khuzestan has been decreased due to heavy leaching and poor drainage management, soil and water salinity has also decreased the productivity in the region.

Fig. 2: Area Harvested, Production and Yield of sugarcane in Iran

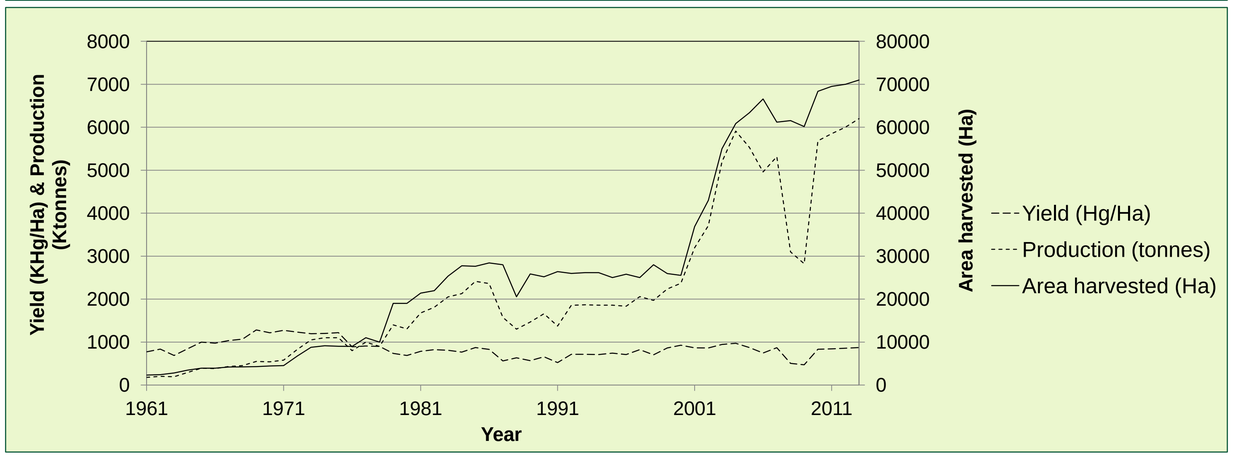


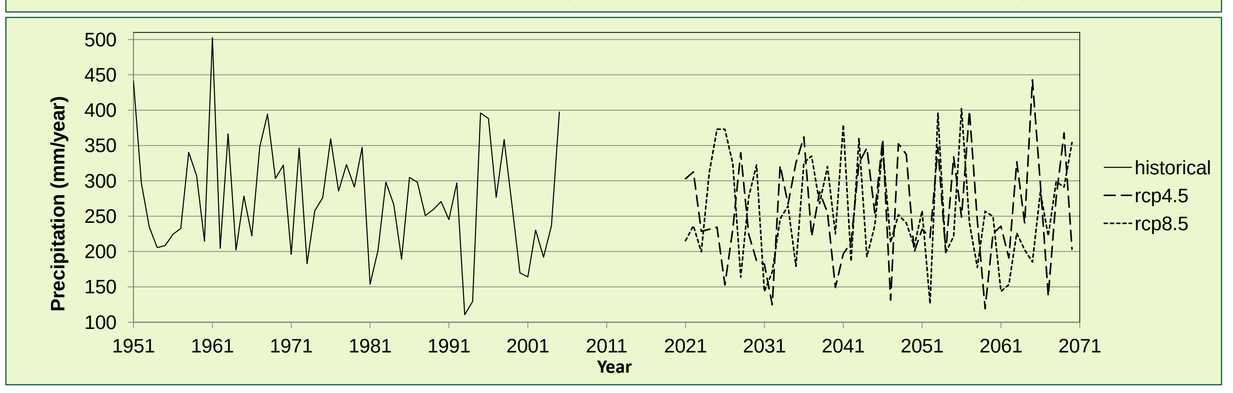
Table 2: Iran's sugarcane production compared with other countries in Asia

	2008	2009	2010	2011	2012	2013
Afghanistan	62960	123200	92400	92460	77500	89880
Bangladesh	4983656	5232649	4490812	4671348	4603003	4434000
India	348187900	285029300	292301600	342382000	361037000	341200000
Iran	3097481	2823052	5685088	5850000	6000000	6200000
Nepal	2485437	2354412	2592500	2718226	2930047	2930000
Pakistan	63920000	50045400	49372900	55308500	58397000	63749900
Sri Lanka	799450	919530	914850	729010	673470	700000

To study feasibility of sugarcane cultivation in Khuzestan, the changes in precipitation values under climate change have been compared with the current climatic precipitation values. The future projected climate data were retrieved from EC-EARTH database, and downscaled in Coordinated Regional Climate Downscaling Experiment (CORDEX) project to spatial resolution of 0.44 and daily temporal resolution, under two representative concentration pathway scenarios of IPCC AR5, RCP 4.5 and RCP 8.5, for base line period of 1951-2005.This baseline data that were used to calibrate the projected data, during five decades from 2021 to 2070 to detect any changes in precipitation values. Besides the climatic data of 5 synoptic stations (table1) were used to calibrate downscaled historical generated data. Using past period calibrated data, the future projections were calibrated accordingly. Figure 3 shows the historical and future projections of precipitation under two climatic scenarios.

Results and Discussion:
The historical data of fig 3 (1951-2005) show a decreasing trend in rainfall. The mean value for entire period is 274 mm but during the last 15 years (1991-2005) the mean rainfall is about 257 mm comparing the future estimated data during 2021 to 2070 under two climate change scenarios, rcp 4.5 and rcp 8.5, with average values of 258 and 255 mm, respectively. Therefore, apparently no specific change in the precipitation is expected comparing to recent two decades mean. According to figure 2, as the yield of sugarcane has no change in last decades, it's clear that increasing in sugarcane production is the result of increased cultivated area, many studies in the region have revealed that despite increase in cultivated land, due to poor management and soil / water salinity the yield has not increased significantly. Considering the projections of no change in precipitation values during future decades, under current management practices, more water salinity and decreasing sugarcane yield is expected. The other affecting climatic variable i.e. temperature, is expected to increase in the region, and as a result, the growing degree day (GDD) for growing period will be will be maintained sooner, which in turn causes a drop in yield of the crop. Therefor new management otpions such section of new varites, changing the crop calendar and better improved soil water management should be adopted. Further studies using another scenarios and climatic variable are recommended for more security.

Fig. 3: Precipitation values under rcp4.5 and rcp8.5 climate change scenarios over Khuzestan province



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