Short communication

Climate change and it's impact on cropping pattern: A case study of Tawa canal command, Madhya Pradesh, India

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Irrigation command areas are planned based on the reservoir water availability, and accordingly designed cropping pattern is suggested. Often, climate variability affects the demand and supply driven command operation, forcing farmers to adopt alternative cropping pattern. To arrive at possible reasons of change in the cropping pattern in the Tawa irrigation system, the present study assessed the existing and designed cropping pattern using IRS 1B LISS I and IRS P6 LISS III datasets. Also the rainfall and temperature trend have been investigated using parametric and non-parametric statistical tests for the period 1971 to 2010 system, to conclude whether the farmer's adoption to different crops is driven by climate change or some other aspects. It is true that there is no scientific basis or climatic basis of change in cropping pattern in a command, however, it cannot be denied in totality. Climate is a complex phenomenon and continuously changes spatially and temporally affecting agriculture. Even with minor deviations from the normal weather, significant changes happened in the crop production and productivity. This drives omission and adoption of different crops in a region. The impact of climate change affects water resources and many other sectors including agriculture, forestry, health, fresh and marine aquaculture, etc. (IPCC, 2007). With the growing concern about climate change impacts, researchers have employed the nonparametric Mann-Kendall test (Mann 1945; Sen 1968; Kendall 1975) to identify whether monotonic trends exist in hydro meteorological data such as temperature, precipitation and stream flow (González et al., 2008; Conway et al., 2009). Many studies are also reported on trend analysis of rainfall and temperature in different parts of India (Kumar and Jain, 2010; Rai et al., 2010; Patra et al., 2012).

Cropping pattern in the command

The cropping pattern in command area of irrigation projects generally changes with the change in resources availability. These changes are gradual and takes five to ten years to reflect on larger scale statistics. To compare the pattern of change, IRS 1B LISS I and IRS P6 LISS III datasets for the year 1995-96 and 2005-06 respectively were utilized. It was clear from the comparison that the area under wheat has increased from 124325 ha to 182866 ha. Also Soyabean crop has been introduced in the command replacing paddy especially during *Kharif* season. This results in considerable change in the cropping pattern vis-à-vis the irrigation requirement.

Rainfall characteristics and trend in the command

The mean annual rainfall in the command is 1174.8 mm with a standard deviation of 302 mm. The annual rainfall variation is significant with a range (maximum-minimum) of 1245.8 mm. The annual dependable rainfall with a probability of 75% is 989.6 mm. A low coefficient of variation (27.9%) during monsoon in comparison to other seasons suggests a dependable monsoon in the region. Winter witnesses 5% of annual rainfall in the command, indicating total dependency of irrigation water by the crops grown during the period. The mean annual rainfall in the region showed an insignificant declining trend at 5% significance level during the period 1971-2010. The Mann-Kendall trend analysis for the periods during monsoon and winter showed insignificant declining trend, however, the pre-monsoon period indicated an increasing rainfall trend at 5% significance level. The increasing rainfall trend in the summer (pre-monsoon) may be due to the local disturbances boosted by the extreme temperature in the region. The monthly rainfall trend indicated that two of the four monsoon months (June and August) showed decreasing trends, whereas increasing trend was found for the months of July and September. A decreasing rainfall trend in the month of June may severely affects the initial field preparation for monsoon crops resulting in delayed sowing. As generally seen and confirmed by the local farmers in command, late sown crops are weak in nature, and often attract pests and insects. This results in low crop production. Due to the decline June rainfall, entire crop period may need to be shifted in the region by one or two weeks to accommodate the rain. An increasing trend in the month of July augurs well for the crops grown; however, a declining August trend again puts pressure and may bring water stress condition during peak crop growing period. An undulating monthly trend in the four *Kharif* months indicated the climatic variability likely to be witnessed in the region. The trend for the months of October to February (*Rabi* season) is encouraging in the region. However, the initial increasing trends for the months of October and November may induce post-harvest losses for the *Kharif* crops. The rainfall characteristics and rainfall trend statistics for the period 1971 to 2010 is presented in Table 1.

Table 1: Monthly, seasonal and annual rainfall characteristics and trend statistics for the period 1971-2010

Month	**Rainfall characteristics and trend statistics**								
	Mean (μ)	75% probability	% contribution to annual	Slope	t Stat	P-value	MK	Sen's Slope	Year of change
Jan	4.5	0.10	0.49	-0.04	-1.52	0.14	0.64	0.00	1993
Feb	56.6	1.10	0.39	-0.01	0.13	0.89	-0.30	0.00	1979
Mar	5.3	0.80	0.45	0.27	-0.95	0.35	1.06	0.01	2004

Apr	0.8	0.20	0.07	0.04	2.37	0.02	2.56*	0.00	2000
May	6.3	0.00	0.53	0.20	0.08	0.93	0.63	0.01	2000
Jun	169.9	57.71	14.47	-0.09	1.02	0.31	-0.62	-1.12	1981
Jul	330.9	227.63	28.17	1.43	1.47	0.15	0.41	0.68	1992
Aug	404.3	269.85	34.41	-5.55	-3.36	0.00	-1.78	-4.38	1994
Sep	200.6	78.36	17.07	2.04	-0.81	0.42	0.69	1.17	1992
Oct	26.5	0.25	2.26	0.30	0.05	0.96	0.67	0.05	1981
Nov	11.7	0.00	0.99	-0.04	-0.73	0.47	1.11	0.00	2001
Dec	8.1	0.00	0.69	0.00	0.09	0.93	-0.04	0.00	2001
Annual (Jan-Dec)	1174.9	989.57	100.00	-1.4	2.12	0.04	-0.94	-3.88	1986
Monsoon (Jun-Sep)	1105.7	896.81	94.12	-2.14	-0.50	0.62	-1.34	-5.06	1986
Winter (Oct-Feb)	56.6	20.89	4.82	0.20	-2.23	0.03	-0.17	-0.06	1990
Summer (Mar-May)	12.4	0.33	1.06	0.51	-0.66	0.51	1.50	0.07	2003

* trend at α = 0.05 level of significance; # trend at α = 0.1 level of significance

Temperature characteristics and trend in the command

The mean annual temperature across the Tawa command is 29.6°C with a standard deviation of 0.4°C. The temperature starts rising from beginning of February and peak is reached in the month of May touching the mercury at 41ºC (Normal). The winter season commences during November and temperature dips to 11ºC in the month of December. The temperature characteristics in the region can be summarized as extreme with intense summer and winter periods. The temperature trend in the region indicated an increasing trend excepting for the month of April. The minimum temperature series increases more significantly than the maximum and average series. This indicates higher temperature variability between maximum and minimum temperature in the region. The increasing temperature trend in the region will require higher crop water requirement with high evapotranspiration values. This will further increase the gap between water demand and supply in the command. The effect of higher temperature in the crop production and productivity is yet to be established in the region, but certainly an increase demand of water will further exaggerate the water stress. The temperature characteristics and trend statistics for the region are presented in Table 2.

Table 2: Monthly, seasonal and annual temperature characteristics (minimum, maximum and average) and trend statistics for the period 1971-2002

Month	**Temperature characteristics an trend statistics**								
	Mean (μ)			MK statistics			Sen's slope		
	T_{min}	T_{max}	T_{avg}	T_{min}	T_{max}	T_{avg}	T_{min}	T_{max}	T_{avg}
Jan	11.7	27.1	19.4	1.05	1.44	1.31	0.01	0.03	0.02
Feb	13.6	29.9	21.7	0.71	0.89	0.79	0.02	0.02	0.02
Mar	18.3	34.9	26.6	0.02	0.02	0.21	0.00	0.00	0.00
Apr	23.2	39.2	31.2	-0.36	-0.36	-0.31	-0.01	-0.01	-0.01
May	26. 7	40.9	33.8	0.70	0.70	0.96	0.02	0.02	0.02
Jun	25.4	36. 8	31.1	0.00	0.00	0.08	0.00	0.00	0.01
Jul	23.1	30.5	26.7	0.92	0.92	0.92	0.01	0.01	0.01
Aug	22. 6	28.8	25.7	1.54	1.54	1.56	0.02	0.02	0.02
Sep	22.9	30.8	26.4	1.05	1.05	1.28	0.02	0.02	0.02
Oct	18.8	32.5	25.6	1.77	1.83	1.86	0.03	0.03	0.03
Nov	14.7	29.7	22.1	1.96	2.03	1.93	0.05	0.04	0.05
Dec	11.7	27.0	19.4	1.78	2.03	1.86	0.04	0.04	0.04
Annual (Jan-Dec)	22.6	36.6	29.6	2.68	1.99	2.38	0.02	0.02	0.02
Monsoon (Jun-Sept)	31.1	42.3	36.6	1.51	1.12	1.35	0.03	0.02	0.02
Winter (Oct-Feb)	14.1	29.3	21.6	1.90	2.16	2.03	0.02	0.03	0.03
Summer (Mar-May)	22.7	38.4	30.5	0.89	0.21	0.42	0.01	0.00	0.01

Tawa canal command was commissioned after 1978. During the last three decades, significant changes have taken place in the existing cropping pattern and the design cropping pattern. As cropping pattern change is due to multiple of reasons, impact of climate change cannot be ruled out. Along with the socio-economic factors, a favorable climate for a particular crop, here, Soyabean drives the cropping pattern. The findings of trend analysis can be interpreted in many ways. A declining trend for the month of June will not only hamper the field preparation works before the *Kharif* season but also trigger shift in the crop periods in the command area. An increasing trend of temperature will boost higher evaporation as well as evapotranspiration, which can only be compensated through higher crop water requirement if the crops to sustain. The study confirms the altered cropping pattern in the command due to multiple of reasons including climate driven by rainfall and temperature.

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