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Impact of climate change on water resources and cropping pattern in Karnataka

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Abstract: The present study was done to decipher the impact of climate change on water resources and cropping pattern in Karnataka using the secondary data. Tabular analyses have been used to derive valid conclusions. The two important river basins of the state, Krishna and Cauvery, were selected for the present study. Between the two river basins, the increase in runoff and decrease in evapo-transpiration in the Krishna basin is higher, implying higher water stress and potential of droughts in the Krishna basin than in the Cauvery basin. The predominant crops such as rice, banana and sugarcane in both the Krishna and the Cauvery river basins being water-intensive crops will be affected negatively by the increased moisture stress in the near future, leading to reduced yields and change in cropping patterns.

Keywords: Evapo-transpiration, Precipitation, Runoff, Water yield

Introduction

The impacts of climate change on water resources have been highlighted in the Fourth Assessment Report of the Inter-governmental Panel on Climate Change (IPCC), which predicts an intensification of the global hydrological cycle, affecting the supply of both the ground water and surface water. The IPCC report also concluded that it is highly likely "The negative impacts of climate change on freshwater systems outweigh its benefits", with runoff declining in most streams and rivers. In addition, different catchments are likely to respond differently to the same change in climate drivers, depending largely on catchment physio-geographical and hydro-geological characteristics and the amount of lake or groundwater storage in the catchment. The IPCC has predicted with high confidence that the drought affected areas will show increase in frequency as well as the severity of drought. The IPCC also predicts with high confidence that the area affected by drought will increase in South Asia, including India. The impacts of climate change are also dependent on the baseline condition of the water supply system and the ability of water resource managers, to respond to climate change in addition to pressures of increasing demand due to population growth, technology, and economic, social and legislative conditions (Gosain *et al.,* 2006).

There are seven river systems in Karnataka namely Krishna, Cauvery, Godavari, North Pennar, South Pennar and Palar. The annual average yield in the seven river basins is estimated to be 98,406 Million Cubic Meters (MCM). However economically utilizable water for irrigation is estimated at 1,695 Thousand Million Cubic feet (TMC). According to the Karnataka State Environment Report (2003), there are 36,679 tanks in the state with an irrigation potential of 6,84,518 ha (0.6 Mha) and minor irrigation surface tanks with estimated irrigation potential at about 1.0 Mha.

Two important river basins of the state, Krishna and Cauvery, account for nearly 78% (Krishna- 59.60%, Cauvery-18.34%) of the total basin area of Karnataka.

Krishna river basin is the fourth largest in India in terms of annual discharge and fifth largest in terms of surface area, covering parts of three states in South India. It covers approximately 59% of the geographic area of Karnataka. The principal tributaries of Krishna in Karnataka are Ghataprabha, Malaprabha, Bhima and Tungabhadra. The main issue facing the river basin is that the construction of large dams on the river for generation of hydroelectricity has severely reduced the river discharge. In a study done by Bouwer *et al.* (2006) it was observed that climate variability varied the runoff by 6-15% while the construction of reservoir on the river decreased the runoff by 61%.

The Cauvery river basin (Fig. 1) is the second major river system in Karnataka. It covers approximately 18% of the geographic area of Karnataka. The principal tributaries of Cauvery in Karnataka are the Harangi, the Hemavathy, the Lakshmanathirtha, the Kabini, the Shimsha, the Arkavathi and the Suvarnavathi. All these rivers, except the Kabini, Arkavathi and Suvarnavathi rivers, rise and flow fully in Karnataka.

Material and methods

The two important river basins of the state, Krishna and Cauvery, were selected for the present study. This study aims to assess the impact of climate change on water resources on these two river basins. This study will address:

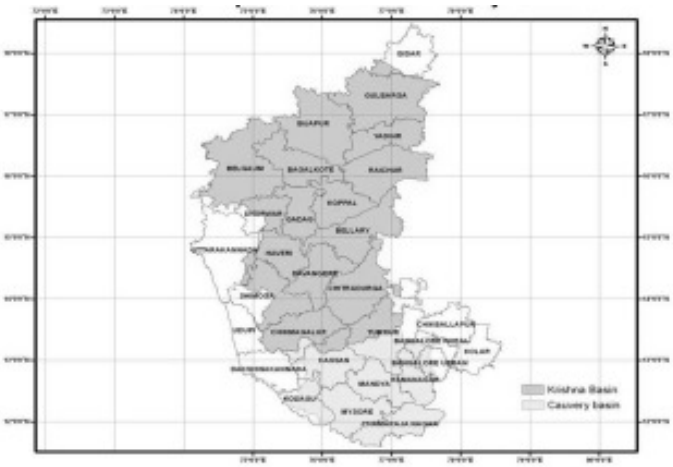

Fig. 1. Location map of Krishna and Cauvery basin in Karnataka

Table 1. River systems of Karnataka, their average yield, area drained and percentage of water yield (Source: Department of Water Resources, Karnataka)

River system	Estimated average yield (Million cubic meters)	Drainage area (1000 km²)	Percentage of average yield
Krishna	27,451	113.29	27.90
Cauvery	12,304	34.27	12.33
Godavari	1,415	4.1	1.44
West flowing rivers	56,600		57.51
North Pennar	906	6.94	0.92
South Pennar		4.37	
Palar		24.25	
Total	98,406	190.50	100.00

- Precipitation in the two river basins
- Runoff or water yield
- Evapo-transpiration

Krishna and Cauvery river basins have been selected for the study. These two are the major basins in the state accounting for nearly 78 per cent (Krishna- 59.60 per cent, Cauvery- 18.34 per cent) of the total basin area of Karnataka. It can be observed from Table.1 that Krishna and Cauvery river basins are the largest, in terms of the area drained in the state.

An assessment of the impacts of climate change on water resources can be best handled through modeling of hydrological conditions in river basins under future predicted climate variables. The main components of the hydrological cycle are precipitation, evaporation and transpiration. Changes in climate parameters, solar radiation, wind, temperature, humidity and cloudiness affect evaporation and transpiration. The river basin is generally the most appropriate primary exposure unit for assessing impacts on hydrological resources. For the present study, three variables *i.e.* precipitation, evapo-transpiration and surface runoff have been considered.

Precipitation is any product of the condensation of atmospheric water vapour that falls under gravity. It manifests mostly as rainfall in a region.

Evapo-transpiration (ET) is a term used to describe the sum of evaporation and plant transpiration from the Earth's land surface to atmosphere. Evaporation accounts for the movement of water to the air from sources such as the soil, canopies, and water bodies. Transpiration accounts for the movement of water within a plant and the subsequent loss of water as vapour through stomata in its leaves.

Surface Runoff is the water flow that occurs when soil is infiltrated to full capacity and excess water from rain, melt water, or other sources flows over the land.

The data used for the study include: current observed temperature and precipitation: the 30-year climatological data was used.

Results and discussion

Impact of climate change on the water sector

An investigation of the percentage changes of the three variables - ET, Runoff, and Precipitation is conducted for both Krishna and Cauvery basins.

Krishna basin

Precipitation: Fig.2 indicates that on an average, annually, there would be a decrease in precipitation. Investigating further, there is a decrease in precipitation in the monsoon/*Kharif* season, whereas there is an increase in precipitation in the post monsoon/*Rabi* season, however, percentage-wise, the increase and decrease is very low.

Runoff **:** There is an increase in annual runoff in the Krishna basin, the percentage increase in runoff annually, is on an average 3 per cent. There is high increase in runoff in the monsoon/*Kharif* season (around 5 per cent average). However it can be observed that there is a decrease in runoff in the post-monsoon/*Rabi* season (around 2 per cent average).

Evapo-transpiration **:**There is a decrease in the rate of evapo-transpiration in the Krishna basin. Specifically an annual decrease of 6 per cent is observed, the *Kharif* season decrease is on an average around 4 per cent, while the Rabi season decrease is higher in absolute value, and around 6 per cent on an average. This evapo-transpiration decrease may be indicative of water stress in the climate change.

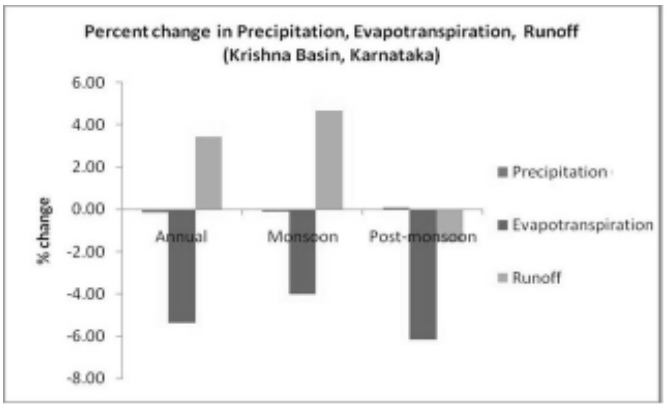

Fig. 2. Percentage change in precipitation, evapo-transpiration and runoff in Krishna Basin of Karnataka

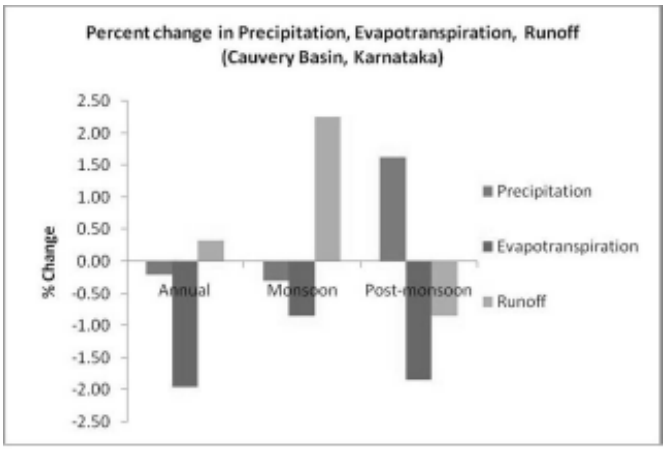

Fig. 3. Percentage change in precipitation, evapo-transpiration and runoff in Cauvery basin of Karnataka

Cauvery basin

Precipitation: On an average, a slight decrease in precipitation annually in the Cauvery basin (Fig.3). There is a decrease in precipitation in the monsoon season, an average of around 0.25 per cent. However there is an increase in precipitation (around 1.75 per cent) in the *Rabi* season. Even though the decrease in precipitation is slight, the decrease in evapo-transpiration and the increase in runoff is a cause of concern, contributing to the uncertainty about the yields in the future in the Cauvery basin.

Runoff **:** There is an annual increase in run off. The average annual increase in runoff is around 0.25 per cent. The runoff increases during the monsoon season, an average of around 2.25 per cent. The runoff decreases in the post-monsoon/Rabi season (0.75 per cent in an average) (Fig.3).

Evapo-transpiration: From Fig.3, it can be observed that there is a decrease (2 per cent) in evapo-transpiration annually. The decrease in evapo-transpiration on an average is around 0.75 per cent in the monsoon/ *Kharif* annually. The decrease in evapo-transpiration was around 2 per cent in the post-monsoon/ *Rabi* season. This decrease in evapo-transpiration in all the seasons is indicative of water stress and is a cause of concern in the Cauvery watershed.

Overall, among the two river basins, the increase in runoff and decrease in evapo-transpiration in the Krishna basin is higher in absolute terms when compared to the Cauvery basin on an average, implying higher water stress and potential of droughts in the Krishna basin.

Effect of Climate Change on Water Resources of Karnataka and Impacts on Cropping Pattern

Krishna basin

Due to basin closure and high irrigation development in the Krishna basin, the stream flow to the oceans is only 20 per cent of pre-irrigation discharge of the river. There are competing demands for irrigation from the tributaries, which is causing increasing basin closure in the tributaries as well (Biggs *et al.,* 2005). The increasing source of irrigation for crops in this location is groundwater. The major results of this study show that there will be a decrease in precipitation, slight increase in runoff and water yield and decrease in evapo-transpiration in the short–term. This is indicative of additional water stress in the future. The major crops cultivated in Krishna basin are rice and other grains, sugarcane, banana and other cash crops. These are all water-intensive in nature of cultivation, and therefore the increasing water stress is predicted to have negative effect on these crops, creating possible changes in cropping pattern and species cultivated.

Cauvery basin

The results of the assessment of the impact of climate change on the Cauvery basin indicates that decrease in precipitation in the basin, slight increase in runoff and water yield and a decrease in the evapo-transpiration. This will affect the crops that are cultivated in the region. The major crops grown in the Cauvery region are rice, sugarcane, ragi, jowar and cash crops such as coffee, pepper and banana. The staple crops such as rice and the other crops such as sugarcane and the cash crops are water-intensive in cultivation. Thus the increasing water stress in the region is predicted to affect the crops in the region negatively, leading to changes in the species cultivated.

Climate change impact assessment indicates increased moisture stress in the Krishna basin, especially in the north-eastern districts, and marginal impact in the Cauvery basin. The water yield analysis indicates an increase in average water yield in the Krishna basin, while indicating a decrease in average water yield in the Cauvery basin. The precipitation analysis indicates: Decrease in precipitation annually around 0.25 per cent in the Krishna as well as Cauvery basins. The runoff analysis indicates an increase in average annual runoff for both the river basins. The average annual runoff is much higher in the Krishna basin than in the Cauvery basin. This indicates that the water stress in Krishna basin would be much higher and farmers residing around the Krishna basin may suffer reduced crop yields in this year to come. The evapo-transpiration analysis indicates a decrease in evapo-transpiration annually in both the river basins. The predominant crops such as rice, banana and sugarcane in both the Krishna and Cauvery river basins being water-intensive, will be affected adversely by the increased moisture stress in the near future, leading to reduced yields and change in cropping patterns.

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