The Pharma Innovation Journal 2023; 12(5): 4250-4253

www.ThePharmaJournal.com

The Pharma Innovation

ISSN (E): 2277-7695
ISSN (P): 2349-8242
NAAS Rating: 5.23
TPI 2023; 12(5): 4250-4253

www.thepharmajournal.com
Received: 07-03-2023
Accepted: 16-04-2023

S Senthilnathan
Department of Agricultural Economics, Agricultural College and Research Institute, Killikulam, Vallandu, Tamil Nadu, India

V Saravanakumar
Department of Agricultural Economics, Horticultural College and Research Institute, Periyakulam, Theni, Tamil Nadu, India

M Prahadeeswaran
Department of Agricultural Economics, TNAU, Coimbatore, Tamil Nadu, India

D Rameshkumar
Assistant Professor, SRM College of Agricultural Sciences, SRM Institute of Science Technology, Vendhar Nagar, Baburayanpettai, Chengalpattu, Tamil Nadu, India

Corresponding Author:
S Senthilnathan
Department of Agricultural Economics, Agricultural College and Research Institute, Killikulam, Vallandu, Tamil Nadu, India

Impact of climate change on water availability and water resources in India: A review

S Senthilnathan, V Saravanakumar, M Prahadeeswaran and D Rameshkumar

DOI: https://doi.org/10.22271/tpi.2023.v12.i5ax.20440

Abstract
Irrigation water accounts 90% of total global consumption. The increasing trend of surface warming during the end of the century would result in an increase in pre-monsoonal and monsoonal rainfall and no substantial change in winter rainfall over the Indian subcontinent. This would result in an increase in the monsoonal and annual run-off and the increase in evaporation and soil wetness during the monsoon on an annual basis.

Keywords: Climate change, impact, India, water resources

Introduction
Irrigation water withdrawals account for 70 percent of global water withdrawals and 90 percent of global consumptive water use (Shiklomanov and Rodda, 2003) [16]. Water use has increased over the last decades due to demographic and economic growth, changes in lifestyle, and expanded water supply systems. Generally, irrigation water requirement increases with temperature and decreases with precipitation. In semi-arid regions, climate change may prolong the dry season and affects the water users to depend on reservoirs or deep groundwater wells (Giertz *et al.*, 2006) [6]. It is important to examine the various direct and indirect effect of climate change on the water sector in general and the irrigation resources in particular.

Impact of Climate Change
The Sustainable freshwater resources management has gained significant importance at global level and integrated water resources management has emerged as the corresponding scientific paradigm. The effect of climate change on stream flow and groundwater recharge varies due to projected changes in precipitation. In general, higher water temperatures are likely to worsen the quality of the water. In most places, magnitude of flood and frequency are projected to grow, whereas low flow levels are probably going to decline. Water demand is rising globally due to economic expansion and population growth, although it is declining in some nations as a result of improved water usage efficiency (Palanisami *et al.*, 2010) [13]. The characteristics of the system, shifting demands imposed on the system, management of the existing system and the climate change adaptation strategies have an important role in magnitudes of climate change on water resources.

Surface and Ground Water Resources
The changes in precipitation amount, timing and intensity will affect river flows as well as lake and wetland levels due to climate change. River catchments react to the changes in climatic drivers, mostly depending on the physiogeographical and hydrogeological characteristics of the catchment. Groundwater systems generally respond more slowly to climate change than surface water systems. Groundwater levels are strongly correlated with precipitation, but shallow aquifers affected significantly with temperature. Droughts have an impact on water supplies for domestic, industrial, and agricultural uses as well as rain-fed agriculture. Semi-arid and sub-humid regions have seen more severe and multi-annual droughts, demonstrating their susceptibility to future increases in drought incidence predicted as an effect of climate change (Nicholson, 2005) [10].

Water Use and Availability

Water demand has increased during the past few decades due to changes in lifestyle, demographic and economic growth, and the expansion of water delivery systems. Irrigation water use generally rises with temperature and decreases with precipitation. This is brought on by the fact that non-climatic factors mostly determine water usage as well as the quality of water. The length of the dry season may vary due to climate change in semi-arid regions, which will harm water consumers who depends on reservoirs and open wells. Human beings are suffering from a lack of water and natural ecosystems in many river basins (Giertz *et al.*, 2006) [6]. Currently, human beings and natural ecosystems in many river basins suffer from a lack of water. In global-scale assessments, basins with water stress are defined either as having per capita water availability below 1,000 m^3/year. These river basins are located in Africa, China, Australia, Mediterranean region, South Asia, USA, Mexico, North-eastern Brazil and Western coast of South America.

Climatic and Non-Climatic Drivers

The precipitation, temperature, evapotranspiration, atmospheric humidity and wind speed are the major climatic drivers for water availability in different regions of the world. Temperature has significant role in snow dominated river basins. Globally, many non-climatic drivers affect the freshwater resources and coastal regions. Water resources are influenced by land-use change, construction and management of reservoirs, pollutant emissions and wastewater treatment. Water uses are depends on population, food consumption, technology, lifestyle and society's views on the value of freshwater. Vulnerability of freshwater availability to climate change also depends on adaptation and management water resources. The integrated water resources management which prioritises the water as a resource and a habitat in policymaking. As a result, freshwater systems will probably be less vulnerable to climate change. Water saving technologies and water pricing has to be adopted during the prioritization of domestic and industrial water supply over irrigation water supply.

Along with intensive agriculture, water use efficiency on irrigation activities, the size of future irrigated lands will be the main determinant of future irrigation water usage. Food and Agriculture Organization predicted that developing nations are anticipated to increase their irrigated area by 0.6% per year until 2030 and water-use efficiency for irrigation also will rise moderately (Alexandratos and Bruinsma, 2012). Given the predominance of irrigated area under water usage, management strategies that boost irrigation water efficiency can significantly enhance the amount of water available for other uses by people and the environment (Tiwari and Dinar, 2002) [17]. The irrigation sector's water demands will be most heavily affected due to climate change and changes in efficacy of modern irrigation technologies. Changes in irrigation water demand, management changes and availability of water will work together to influence changes in irrigation water usage in places with limited water resources (Senthilnathan *et al.*, 2018) [14].

The variability of temperature and precipitation increase the irrigation water demand, even if the same amount of total precipitation received during the partiular growing season. The rising atmospheric CO_2 concentrations, water use efficiency for plants would increase the ratio of crop output to per unit of water input. In the hot regions of the world, such as Egypt, the ratio may decline as yields decreases.

Additionally, increasing evapotranspiration brought on by climate change is predicted to have a significant impact on both the salinization of groundwater and the incursion of saltwater into aquifers. Sea level rise affect the ground water resources negatively and saline water seeps into fresh groundwater which made worse in groundwater recharge (Bobba *et al.*, 2000) [3]. To address the water shortage, adaptation of water saving technologies are necessary. However, the adaptation and mitigation strategies in the water resources sector entails both actions to adjust human demands on water availability and actions to adjust hydrological characteristics to encounter the human demands (Sarwary *et al.*, 2022) [15].

Water Resources and Estimated Future Water Requirement in India

The available, utilizable and present utilization for different purposes of water resources in the country is given in Table 1. Out of the utilizable flow of 1122 b.cu.m, only 605 b.cu.m is presently used in which irrigation accounting for the major share. The groundwater resources have two components which are static and dynamic. The static fresh groundwater reserves (aquifer zones below the zone of groundwater table fluctuation) of the country have been estimated as 10812 b.cu.m. The dynamic component is replenished annually, which has been assessed as 432 b.cu.m.

Table 1: Water resources of India

S. No	Particulars	Unit (b.cu.m.)
1	Annual precipitation	4000
2	Available water resources	1869
3	Utilizable	1122
4	Surface water (storage and diversion)	690
5	Groundwater (replenishable)	432
6	Present utilization (Surface water 63%, groundwater 37%)	605
7	Irrigation	501
8	Domestic	30
9	Industry, energy and other uses	74

Source: Central Water Commission, 2002; Mall *et al.*, 2006

According to the National Water Policy (2002), development of groundwater resources is to be limited to utilization of the dynamic component of groundwater. The falling groundwater levels in various parts of the country have threatened the sustainability of the groundwater resource, as water levels have gone deep beyond the economic lifts of pumping. Central Ground Water Board has identified significant decline in the level of groundwater in several pockets of 289 districts of our country (CGWB, 2002).

National Commission for Integrated Water Resources Development estimated the water requirements for the years 2025 and 2050 at the national level were given in Table 2.

Table 2: Water requirement for different uses (b.cu.m)

Use	1997–98	2025	2050
A. Surface water			
Irrigation	318	366 (43)	463 (39)
Domestic	17	36 (5)	65 (6)
Industry	21	47 (6)	57 (5)
Power	7	26 (3)	56 (5)
Inland navigation	-	10 (1)	15 (1)
Environment ecology	-	10 (1)	20 (2)
Evaporation loss	36	50 (6)	76 (6)
Total (A)	399	545 (65)	752 (64)
B. Groundwater			
Irrigation	206	245 (29)	344 (29)
Domestic and municipal	13	26 (3)	46 (4)
Industry	9	20 (2)	24 (2)
Power	2	7 (1)	14 (1)
Total (B)	230	298 (35)	428 (36)
Grand total (A + B)	629	843 (100)	1128 (100)
Total water use			
Irrigation	524	611 (72)	817 (68)
Domestic	30	62 (7)	111 (9)
Industry	30	67 (8)	81 (7)
Power	9	33 (4)	70 (6)
Inland navigation	0	10 (1)	15 (1)
Environment ecology	0	10 (1)	20 (2)
Evaporation loss	36	50 (6)	76 (7)
Total	629	843 (100)	1180 (100)

Figures in parentheses indicates percentage to total
Source: Ministry of Water Resources, 1999

Conclusion

Surface temperature and variability of many other climatic parameters during the end of the century result in increasing the monsoonal rainfall and hence it is important to examine the impact of climate change on water resources sector. The anticipated changes in future precipitation, the impact of climate change on surface and ground water recharge differs regionally and geographically. Generally, the water use rises with warming conditions and falls with precipitation. Many climatic and non-climatic drivers affect water resources and hence it is important to follow the adaption and mitigation strategies to manage the water resources in the country.

Adaptation and adaptive capacity - Limitations

There is need for adaptation to manage the water scarcity. However, adaptation in the water sector involves measures to alter hydrological characteristics to suit human demands, and measures to alter demands to fit conditions of water availability. It is possible to identify four different types of limits on adaptation to changes in water quantity and quality (Arnell and Delaney, 2006; Palanisami *et al*., 2012) [2, 11].

- The first is a physical limit: it may not be possible to prevent adverse effects through technical or institutional procedures. For example, it may be impossible to reduce demands for water further without seriously threatening health or livelihoods, it may physically be very difficult to react to the water quality problems associated with higher water temperatures, and in the extreme case it will be impossible to adapt where rivers dry up completely.
- Second, whilst it may be physically feasible to adapt, there may be economic constraints to what is affordable.
- Third, there may be political or social limits to the implementation of adaptation measures. In many countries, for example, it is difficult for water supply agencies to construct new reservoirs, and it may be politically very difficult to adapt to reduced reliability of supplies by reducing standards of service.
- Finally, the capacity of water management agencies and the water management system as a whole may act as a limit on which adaptation measures can be implemented. The low priority given to water management, lack of coordination between agencies, crop diversification, tensions between national, regional and local scales, ineffective water governance and uncertainty over future climate change impacts constrain the ability of organizations to adapt to changes in water supply and flood risk (Palanisami *et al.*, 2009; Ivey *et al.*, 2004; Naess *et al.*, 2005; Crabbe and Robin, 2006) [12, 7, 9, 5].

Research priorities

Research into the water–climate interface is required:

- to improve understanding and estimation, in quantitative terms, of climate change impacts on freshwater resources and their management.
- to fulfill the pragmatic information needs of water managers who are responsible for adaptation
- to know the cost economics of climate change and the adaptation be studied for making the needed interventions.

References

1. Alexandratos N, Bruinsma J. World Agriculture towards 2030/2050: The 2012 Revision. ESA Working paper No. 12-03. Rome, FAO; c2012. p. 1-147.
2. Arnell NW, Delaney EK. Adapting to climate change: public water supply in England and Wales. Climatic Change. 2006;78:227-255.
3. Bobba A, Singh V, Berndtsson R, Bengtsson L. Numerical simulation of saltwater intrusion into Laccadive Island aquifers due to climate change. J Geol. Soc. India. 2000;55:589-612.
4. Central Ground Water Board. Master Plan for Artificial Recharge to Groundwater in India, New Delhi; c2002. p. 115.
5. Crabbe P, Robin M. Institutional adaptation of water resource infrastructures to climate change in eastern Ontario. Climatic Change. 2006;78:103-133.
6. Giertz S, Diekkruger B, Jaeger A, Schopp M. An interdisciplinary scenario analysis to assess the water availability and water consumption in the Upper Oum catchment in Benin. Advances Geosciences. 2006;9:1-11. DOI: https://doi.org/10.5194/adgeo-9-3-2006.
7. Ivey JL, Smithers J, De Loe RC, Kreutzwiser RD. Community capacity for adaptation to climate-induced water shortages: linking institutional complexity and local actors. Environ. Manage. 2004;33:36-47.
8. Ministry of Water Resources Report, National Commission for Integrated Water Resources Development. 1999 September;1:542.
9. Naess LO, Bang G, Eriksen S, Vevatne J. Institutional adaptation to climate change: flood responses at the municipal level in Norway. Global Environ. Change. 2005;15:125-138.
10. Nicholson S. On the question of the recovery of the rains in the West African Sahel. J Arid Environ. 2005;63:615-641.
11. Palanisami K, Ranganathan CR, Senthilnathan S,

Govindaraj S. Economic analysis of climate change impacts on agriculture at farm level. Climate Change in Asia and the Pacific: How Can Countries Adapt; c2012. p. 13.
12. Palanisami K, Ranganathan CR, Senthilnathan S, Umetsu C. Diversification of agriculture in coastal districts of Tamil Nadu–a spatio-temporal analysis. Inter-University Research Institute Corporation. National Institute for the Humanities. Research Institute for Humanity and Nature, Japan; c2009. p. 130-137.
13. Palanisami K, Ranganathan CR, Senthilnathan S, Govindaraj S. Economic impacts of climate change on agriculture in Tamil Nadu: comparison of models using cross section and time series data. In: ADB Workshop on Strategic Assessment for Climate Change Adaptation, Colombo, Sri Lanka; c2010 June 8-11. p. 22. URL: https://hdl.handle.net/10568/38518.
14. Senthilnathan S, Annamalai H, Venkataraman P, Jan H, Narasimhan B. Impact of regional climate model projected changes on rice yield over southern India. International Journal of Climatology. 2018;38(6):2838-2851. DOI: https://doi.org/10.1002/joc.5466.
15. Sarwary M, Senthilnathan S, Saravanakumar V, Arivelarasan T, Manivasagam VS. Climate risks, farmers perception and adaptation strategies to climate variability in Afghanistan. Emirates Journal of Food and Agriculture. 2022;33(12):1038-1046. DOI: https://doi.org/10.9755/ejfa.2021.v33.i12.2797.
16. Shiklomanov IA, Rodda JC, Eds. World Water Resources at the Beginning of the 21st Century. Cambridge University Press, Cambridge, 2003, 435.
17. Tiwari D, Dinar A. Balancing future food demand and water supply: the role of economic incentives in irrigated agriculture. Q. J Int. Agr. 2002;41:77-97.