Multi-Prong Agricultural Water Management Strategies throughWater Resources Assessment - Study from a Coastal District of Odisha (India)

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***Abstract*:**The paper highlights the water resources availability and demand for the state of Odisha (India) considering domestic, crop, livestock and industry sectors. Estimation shows that domestic, crop and livestock water requirement, which is presently 2.172, 46.323 and 0.234 BCM will increase to 2.632, 56.149 and 0.309 BCM, respectively by 2025. Water deficit status showed that by 2025, water demand in the coastal Kendrapara district of Odisha will be high to the tune of 0.689 BCM. Water abundancy during monsoon causing waterlogging and salinity and water deficit during post monsoon causing dwindling crop production will be the key issues. Thus, there is need of multi-prong approaches i.e. emphasis on canal area management with improvement of irrigation infrastructures; popularizing pressurized irrigation system in groundwater exploited area; addressing waterlogged and saline areas through provision of sub-surface water harvesting structures, surface and bio-drainage; and under creek ecosystem, sluice based irrigation system to control salinity.

Keywords: Water availability anddemand;Waterlogged saline area; Pressurized irrigation system; Sluice based technology.

I. INTRODUCTION

Water resources can be neither developed nor managed rationally without an assessment of the quantity of its availability. Lack of understanding on this aspect is an important impediment to the governance, institutional and physical infrastructure reforms. Thus, water resources assessment is a systematic study of the current status and future trends in both water resources and water supply services, with a particular focus on issues relating to availability, accessibility and demand (Batchelor et al., 2005). Whether it is irrigation, flood mitigation, urban and suburban drainage, industrial, domestic water supply and drought mitigation, water resources assessment is essential to the planning, design, construction, operation and maintenance of reliable water systems.Thus, keeping the above issue in mind, this paper reviews the current status of water availability in a water stress Kendrapara district in Odisha (India); its sectoral usage; strategic plan for water smart technologies, which can be taken up in agriculture to attend sustainability. It detailed on sustainable use and strategic planning for the water demand in the district with respect to agriculture, livestock, domestic and industry for the years 2015, 2020, and 2025 based on the availability of the water resources.

II. MATERIALS AND METHODS

1. Study area

Kendrapara, one of the districts (lies in 20° 20’ N to 20° 37’ N latitude and 86° 14’ E To 87° 01’ E longitude) is situated in the eastern Odisha (India) on the east by the Bay of Bengal (Fig. 1). The district with 9 blocks comes in east &south eastern coastal plain with hot & humid climate. The average annual rainfall is 1556 mm. The soil groups are broadly categorized as saline, lateritic, alluvial, red, mixed red & black. In order to quantify the present water availability, basin wise segregation and surface water bodies of different dimensions are generated for the district using Arc GIS (Fig. 2 and Fig. 3).

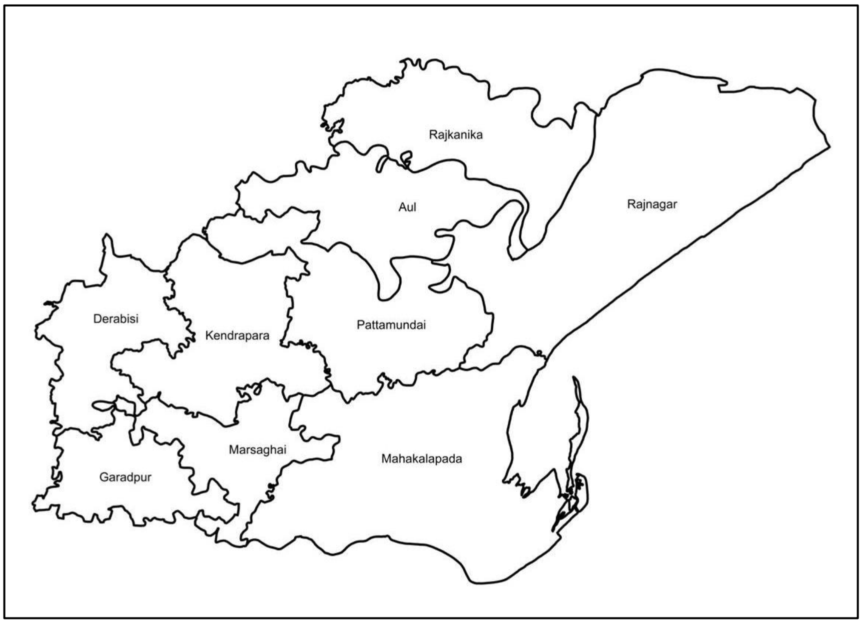

Fig. 1 Kendrapara block map

Basin wise information on surface and groundwater availability for Kendrapara district was collected from the Department of Water Resources, Govt. of Odisha. District wise (Administrative setup) water balance and time trend analysis for future projections were made. Secondary data sources for analysis of water availability and water demand have been considered from printed publications and websites of Government of India. Estimation of the water demand from sources like domestic, livestock, irrigation and industry was made for ascertaining the water demand future scenarios.

1. Domestic water demand

Domestic water demand was estimated based on Census 2011 population data and average water consumption per person per day. From the population figures of 2011 India census, the domestic water demand was computed. The domestic water demand was estimated considering 135 litres of consumption per person per day basis (Shaban and Sharma, 2007). The annual population growth rate from 2001 census to 2011 census was considered as 3% growth rate applied for estimating the population figure for 2015.

2. Crop water demand

Kendrapara falls in agro ecological zone (AEZ) of 12. Hence, contribution of monsoon rainfall is more for agricultural purposes. From long term rainfall data, it showed that 80% of total rainfall is contributed during monsoon season only. Hence, for monsoon crop water requirement, 80% is assumed to be met from seasonal rainfall and hence net crop water demand for monsoon season will be 20% of the total crop water requirement. For *rabi* water crop requirement, 100% is assumed to be met from irrigation source. The projected crop / irrigation water demand was arrived by multiplying the present irrigation water demand (Year 2015 value) by 1.107 (the growth rate for five years is 10.7% as estimated by Planning Commission, Government of India) and was used for estimation of future crop water demand scenario.The values of water requirement given in the Table 1 are taken as reference, while computing crop water requirement. The district and crop wise area sown and the corresponding area under irrigation was computed and the volumetric water demand was then estimated by multiplying the crop water requirement for a particular crop to arrive at total water demand for irrigation for the present cropping area.

S. N.	Crop	Water requirement (mm)
1	Sunflower	300
2	Wheat, Barley, Greengram/Horsegram/Cowpea, Pea, Bengalgram, Rapeseed / Mustard, Sunflower, Castor	350
3	Oats, Ragi, Blackgram, Groundnut, Sesamum, Linseed	400
4	Sorghum, Pearlmillet, Redgram, Lentil, Beans, Soybean, Cabbage	450
5	Maize, Jute	500
6	Cotton, Potato, Onion, Other vegetables	550
7	Tobacco, Chilli, Tomato	600
8	Rice	1100
9	Sugarcane	2000

Table 1 Water requirement of crops (mm) for crop water demand estimation

3. Livestock demand

Livestock data was considered while calculating water demand for various livestock. Table 2 provides amount of water (in litre per day requirement) per specific livestock per day and total water requirement per livestock. Some livestock don't require total 365 days (1 year) lifespan to give marketable produce and hence their estimation for water requirement is considered for actual growing number of days. It is required to multiply the total water requirement with livestock population to get the water requirement value for each specific category. The projected livestock water demand by 2020 was estimated by multiplying the present livestock water demand (base year 2015 value) by 1.15 for future scenario analysis.

S. N.	Name of livestock	Water requirement (litres/day)	Total water demand (litres) / livestock
1	Cattle / Cow / Buffalo (365 days)	30	10950
2	Sheep (270 days)	3.0	810
3	Hen (Broiler) (42 days)	0.2	8.4
4	Hen (layer) (365 days)	0.2	73
5	Pig (365 days)	4.5	1643
6	Goat (270 days)	3.0	810

[1 litre = 10^{-12} Billion Cubic Meter (BCM)]

Table 2 Water requirement of different livestock

4. Industrial water demand

In absence of documented data for district wise industrial water demand, the information published in daily print news media "The New Indian Express" dated 16th June 2017, Page 3, which referred that around 2.608 BCM of water from 11 rivers of the state of Odisha have been provided to various industries, while only 0.283 BCM water is supplied to the public for drinking water purposes. Hence, for balance computation of water resources, industrial water demand of 2.608 BCM was considered for this document. For the present computation of total water resources availability for the selected district, industrial sector is not considered.

Then water gap between availability and demand under the four sectors was computed. Based on the future scenarios, a strategic action plan was proposed.

III. RESULTS

3. Assessment of water resources

Out of the total 10 basins in the state of Odisha, Kendrapara district receives water from Mahanadi, Baitarani and Brahmani basins. A GIS map (Fig. 2) showing basin boundaries is prepared for Kendrapara district by superimposing the district map with the basin map of Odisha state. The results revealed that Baitarani basin, Mahanadi basin and Brahmani basin covers 243.61 sq. km. (total basin area is 14218 sq. km.), 1340.15 sq. km. (total basin area is 141134 sq. km.) and 964.74 sq. km. (total basin area is 39116 sq. km.), respectively in the district.The total cultivated area of the district is 1.52 lakh ha (high land of 0.31 lakh ha, medium land 0.72 lakh ha and low land 0.49 lakh ha). Similarly, the waterbody map (Fig. 3) under GIS platform was prepared, which shown that a total of 1041 nos. of waterbodies having 2178 ha surface area are available (area ≤ 1 ha are 782 nos. and ≥ 1 ha are 259 nos.). The per cent of waterspread area to the cultivated area is deduced as only 1.43%, which implied that there is a great scope for creation of water resources facilities in the district to sustain the crop production.

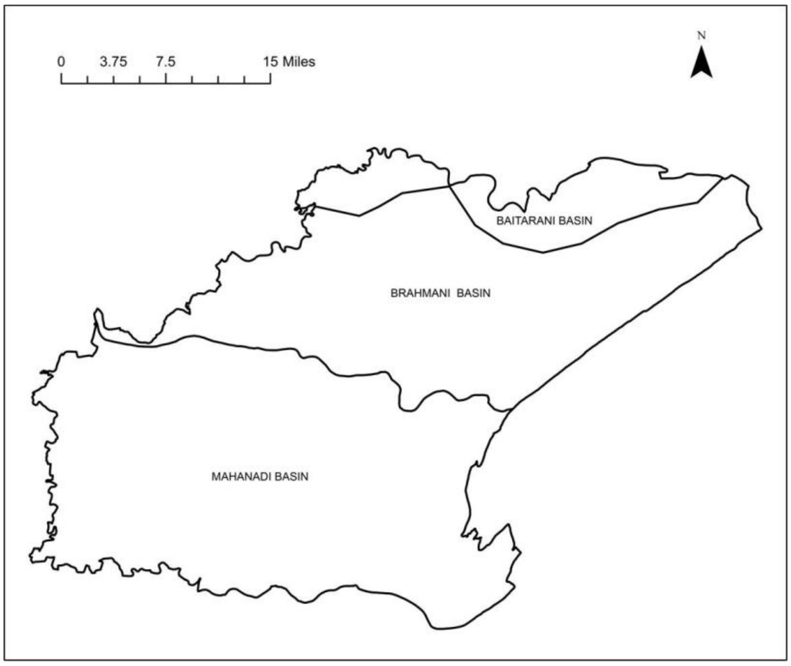

Fig. 2 Basins in Kendrapara district

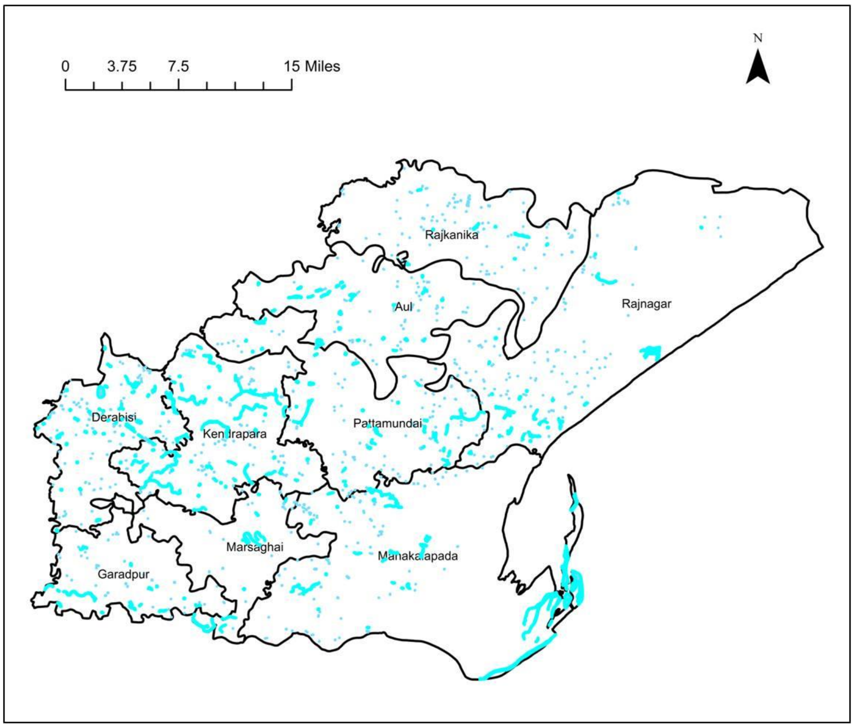

Fig. 3 Waterbodies showing in Kendrapara district map

3.1 Status of surface and groundwater resources

The long term average annual rainfall in the state of Odisha is 1452 mm, which corresponds to an annual rainfall of about 230.76 BCM of water (Annual Report, 2014-15, 2015-16 and 2016-17). Out of total rainfall, a part is lost by evaporation, transpiration and a part add to groundwater through percolation losses and major portion i.e. around 30-40% goes as surface runoff and joins to the Sea. The groundwater storage and surface runoff constitute the water resources of the state. Total surface and dynamic groundwater resources in Odisha are 65.823 BCM and 16.68 BCM, respectively amounting to 82.511 BCM. The surface availability of Kendrapara district is calculated based on proportionate area within the particular river basin of Odisha. The groundwater resources were obtained from the Groundwater Estimation Committee (GEC) assessment available in Groundwater year book of Odisha, 2016-17. The total annual rainfall and total water resource availability of Kendrapara district are 1556 mm and 1.152 BCM, respectively. Out of the available water resources, surface water resources availability is 0.984 BCM and groundwater resources availability is 0.168 BCM (Anonymous, 2019).

3.2 Water demand

3.2.1 Domestic water demand

From the population figures of 2011 census, the domestic water demand was computed. The domestic water demand was then estimated considering 135 litres of consumption per person per day basis. The annual population growth rate from 2001 census to 2011 census (14%) was applied for estimating the population figure for 2015. A demand of 0.075 BCM of water was estimated as the domestic demand for the district for the base year 2015. Further, the projected domestic water demand for the years 2020 and 2025 were estimated based on growth rate of domestic water demand as projected by Planning Commission, Government of India as 0.082 BCM and 0.090 BCM, respectively.

3.2.2 Crop water demand

For *kharif* crop water requirement, 80% is assumed to be met from seasonal rainfall and hence net crop water demand for *kharif* season will be 20% of the total crop water requirement. For *rabi* crop water requirement, 100% is assumed to be met from irrigation source. The projected crop / irrigation water demand by 2020 by multiplying the present irrigation water demand (Year 2015 value) by 1.107 (the growth rate for five years is 10.7% as estimated by Planning Commission, Government of India) could be arrived and was used for estimation of future crop water demand scenario.

A demand of 1.439 BCM of water was estimated as the crop water demand during 2015 for the district. The crop water demand for the years 2020 and 2025 were projected as 1.584 BCM and 1.744 BCM, respectively.

3.2.3 Livestock water demand

Table 2 provides the litre per day water requirement per specific livestock per day and total water requirement per livestock. Considering the daily water requirement of individual livestock, the total water requirement for the livestock for the district as per the present level was worked out to be 0.0055 BCM. The livestock water demand for the years 2020 and 2025 was projected as 0.006 BCM and 0.007 BCM, respectively.

District	Types of water demand	Projected water demand (BCM)		
		2015	2020	2025
Kendrapara	Domestic	0.075	0.082	0.090
	Crop	1.439	1.584	1.744
	Livestock	0.006	0.006	0.007
	Total water demand	1.574	1.672	1.841

Table 4 Water demand under different scenarios

Similarly, basin wise present water demand (2015) from various sectors were shown as in Table 5.

River Basin	Present water demand scenario (BCM)		
	Domestic	Crop	Livestock
Baitarani	0.008	0.139	0.001
Mahanadi	0.039	0.755	0.003
Brahmani	0.028	0.545	0.002
Total	0.075	1.439	0.006

Table 5 Basin wise present water demand scenario

3.3 Water gap

The difference between water demand from all sectors including domestic, crop and livestock and water resources availability showed the water gap for the particular district. The water gap was noticed during present time in the district was -0.367 BCM, which will enhance by 88% during 2025 (Table 6). Thus, there is need of multi-pronged water management action plan to ward off the adverse effects of water deficit situation in agriculture.

	Water demand (BCM)			Water resource availability (BCM)	Water deficit (BCM)		
	2015	2020	2025		2015	2020	2025
Kendrapara	1.519	1.672	1.842	1.152	-0.367	-0.520	-0.690

Table 6 Water deficit scenario

4. DISCUSSION

Having knowing the water deficit status of the district, a multi-pronged strategic approach is foreseen to achieve the future water demand in various sectors. This can be achieved through focus on available water sources vis-à-vis creation of additional water sources, their distribution network and efficient farm level applications. Some of the documentation has already been made through preparation of the District Irrigation Plan (DIP) under PMKSY in the district. Broadly the following proposals have been focused while preparing the district irrigation plan. Creation of new water sources; repair, restoration and renovation of defunct water sources; construction of water harvesting structures, secondary & micro storage, groundwater development, enhancing potentials of traditional water bodies at village level like tanks, ponds etc. Developing/augmenting distribution network, where irrigation sources (both assured and protective) are available or created. Promotion of scientific moisture conservation and run off control measures were aimed to improve ground water recharge so as to create opportunities for farmers to access recharged water through shallow tube/dug wells. Promoting efficient water conveyance and field application devices within the farm viz. underground piping system, drip & sprinklers, pivots, rain-guns and other application devices etc. were focussed. Encouraging community irrigation through registered user groups/farmer producers' organizations and farmer oriented activities like capacity building, training and exposure visits, demonstrations, skill development in efficient water and crop management practices (crop alignment) including large scale awareness on **Per drop More crop** of water were also addressed.

But execution of the activities will not be sufficed for attaining inclusive growth of the district. Timely monitoring of the taken activities and appropriate modus operandi to attain sustainability will be of paramount importance to ward off the future water deficit status in the district. Thus, more specifically, based on the existing cropping intensity (194%), excellent groundwater prospect, presence of a well organised river network to address surface water requirement and coastal agro-climatic condition in the district, the proposed irrigation plan can be thought of considering the following specific action plans viz. pressurized irrigation system in groundwater exploited area; benchmarking of canal command area to know the health of the system and its management and introduction of pipe conveyance irrigation infrastructures (Panda et al. 2018); improving canal performance through canal hydraulic study (Panda et al. 2016); strengthening WUAs; waterlogged area management (Panda et al. 2012) and (Panda et al. 2015) including sub surface water harvesting structures, integrated farming system (IFS); surface and bio drainage provision to address the waterlogged and saline areas; precision land development and modification practices like laser levelling techniques, paired row planting techniques, raised and sunken bed techniques etc. and sluice based irrigation system to control saline water intrusion in creek eco systems. Basin wise planning for developing irrigation infrastructures; especially minor irrigation projects along the side of rivers would be helpful for increasing cropped area. Groundwater potential zones need be exploited for use of groundwater from shallow depth. Simultaneously, conjunctive use of surface and groundwater is proposed for sustainable use of both the resources.

5. CONCLUSIONS

Thus, irrigation plan of a deficit district requires a systematic quantification of its available water resources and various sector future demands. Thereafter, in addition to focussing on the existing water resources infrastructures, macro as well as micro level future plan, its execution, time to time monitoring and prescribing suggestive remedial measures are important aspects to bring inclusive sustainability. However, the action plan requires to address all the water sectors including the industrial sector (as in the present study, it has not been considered) to bring synergy in development.

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