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# Evaluate the hydraulic performance of the minor canal irrigation system in coastal plain region

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**Abstract**
The performance of the Nagpur minor canal (Hirapur and Nagpur village, Block-Baliata, Bhubaneswar Odisha) irrigation system was evaluated during the Rabi season of 2018-19 under the four crops viz. ground nut, pointed gourd, sesame and bitter gourd grown in the command area. The irrigation water requirements for those four crops were calculated using Hargreaves method. The water requirements of these crops viz. groundnut, pointed gourd, sesame and bitter gourd were found to be 45cm, 30cm, 69cm and 58cm, respectively. The performance indicators values in terms of adequacy, equity and relative water supply were computed as 0.31, 0.69 & 0.74 respectively. These values reflect the poor performance of Nagpur minor canal irrigation system. This investigation aimed at improving the capacity of selected minor for proper utilization of canal delivery water and efficient water management for crop production.

**Keywords:** Canal irrigation, hydraulic performance in coastal region

## Introduction
Agriculture is the hub of all strategies planed for development of social economy of the country. Water is the most important natural resources essentials for the existence of life. Increasing the population of India of the utilisation of water is also increasing day by day. In agriculture the huge amount of water use approx. 70-80%.Water plays an importance role in world economy. In present day the less water available for agriculture due to competition of other sectors. One possible approach to conserve water scarce resources might be through improving the performance of existing canal irrigation system. Irrigation canals play a major role for supply of irrigation water from source to agriculture field. Water is distributed from natural source, conveyed, and then diverted through delivery networks to fields. There are wide variations in the water use efficiencies in the canal systems in the country. A case study carried out by ICAR-IIWM, Bhubaneswar in Hirakud canal command area at distributary level revealed conveyance loss of 27.5 $ls^{-1}$ in 100 m and 181.25 $ls^{-1}$ in 100 m in lined and unlined canal sections, respectively. Similarly, irrigation application efficiency is observed within the range between 28.7 –53.1% (Annual Report 2013-14 of ICAR-IIWM). Canal Automation with adequate conveyance *vis-a-vis* pressurized irrigation system application will increase water use efficiency in canal commands, there is no second thought. Thus, the study on water productivity is required to aim to assess the efficiency and to pin point maladies in the system and usher in reforms. Water use efficiency and overall project efficiency in a canal command can be enhanced taking into consideration of water losses (i) in the conveyance and distribution network of canals, (ii) below the outlet into water courses and (iii) on the field. To fulfil future requirement, it is necessary to raise the irrigated area and also raise the efficiency of the irrigation supply system. Proper maintenance and management of irrigation system is necessary for the successful water delivery. Success of an irrigation water delivery can be measured by how much the system is adequate, efficient and delivers water in an equitable manner.

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Description of the Study area

The Study area is located between $85.88^0$ E to $85.84^0$ E longitudes and $22.22^0$ N to $22.20^0$ N latitudes. The study area (20km away from Bhubaneswar), which is located near Khurda district area of Nagpur and Hirapur village, block-Balianta, Bhubaneswar, Odisha. The total length of Nagpur Minor canal is approx 3.02 km. The required data of the study area were collected from the field as well as from the concerned institute/centre.

The experiment (Modelling) was conducted in the Indian Institute of Water Management, Bhubaneswar Odisha. The study area is shown in below figure.

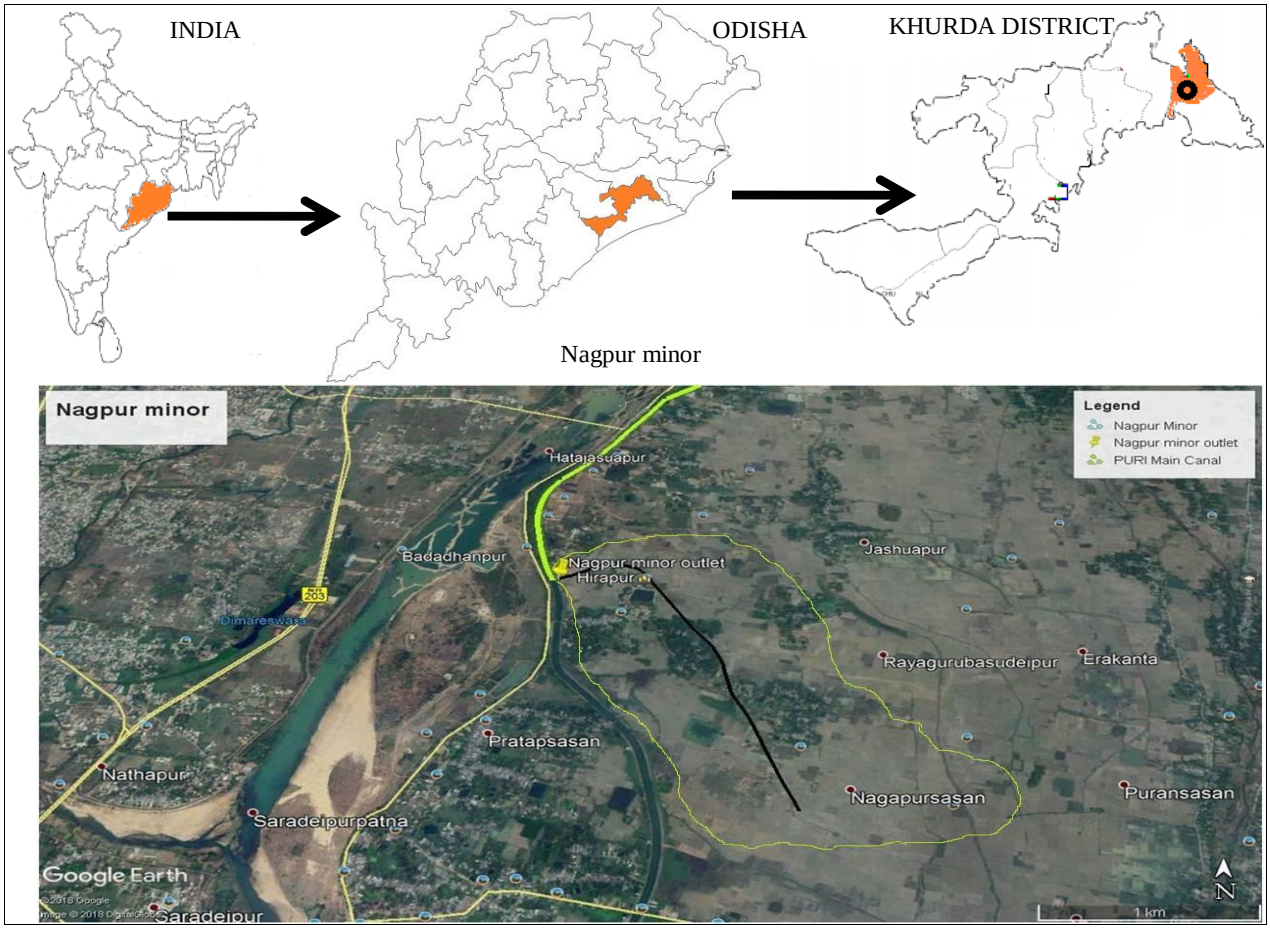


**Fig 1:** Location of the study area

Puri main canal system with its vast network in Odisha caters to the needs of the farming community to varying degrees of success through delivery of water in crop fields. Nagpur minor, one of the minor irrigation system directly off taking from Puri main canal at RD 35.620 km (L)in the district of Khurda (Odisha) located in Hirapur and Nagpur village of block-Balianta having length of approximately 3.02 km; the design Culturable Command Area (CCA) of 156 ha; and design discharge of 0.31 cumec is no exception also. In fact, as per the farmers direct interaction and field visits, the system was found under performing between its demand requirements and actual supply.

**Existing cropping pattern**

On the basis of last five year records obtained from irrigation department and on the basis of information obtained from farmers, the existing cropping pattern found in the command area includes, ground nut, pointed gourd, bitter gourd and sesame in the Rabi season. Total command area is 156 ha were 79.8 ha land used for ground cultivation, 21.5 used for sesame, pointed gourd 17.5 ha land and last 7.8 ha land used for bitter gourd cultivation. 29.4 ha land is blank. As per exiting cropping pattern the maximum area is put under Ground nut in Rabi season. On the basis of information obtained from irrigation department govt. of Odisha. And also from formers the growing season of crops (ground nut, sesame, pointed gourd and bitter gourd) are 5$^{th}$ Jan to 25$^{th}$ April, 20$^{th}$ Feb to 11$^{th}$ May, 15$^{th}$ June to 28$^{th}$ June and 15$^{th}$ Jan to 29$^{th}$ may respectively.

**Materials and Methods**

**Determination of performance indicators**

Adequacy, equity and relative water supply are performance indicators objectives considered when determining irrigation water supply of Nagpur minor canal system.

**Adequacy**

$$P_A = \frac{1}{T}\sum_{T}\left(\frac{Q_{Dt}}{Q_{Rt}}\right)$$

Where,

$Q_{DT}$ = The actual amount of water delivered by the system in the period of the time $t^t$.

$Q_{RT}$ = The amount of water required for the consumptive use, leaching requirement land preparation farm application and conveyance losses downstream of the delivery point in the period of time $t^t$.

T is the sum of all these time periods.

The delivery is considered adequate when $Q_{Dt}$ is equal to $Q_{Rt}$

**Equity**

$$P_A = \frac{1}{T}\sum_{T}\left(\frac{Q_{Dt}}{Q_{Rt}}\right)$$

Where
$CV_R$ ($\frac{Q_{Dt}}{Q_{Rt}}$) is the spatial coefficient of variation of the ratio ($\frac{Q_{Dt}}{Q_{Rt}}$) over the region R. This measure describes the degree of variability in relative water delivery from point to point over the region. The closer value of $P_E$ to zero, the greater the degree of equity

**Relative water supply (RWS)**

$$RWS = \frac{\text{Total water supply}}{\text{crop demand}} = \frac{\text{Irrigation supply + Rainfall}}{\text{CropET + Seepage + Percolation}}$$

**Table 1:** Performance standards for irrigation systems

| Measure | Good | Fair | Poor |
|---|---|---|---|
| $P_A$ | 0.90-1.0 | 0.80-0.89 | <0.80 |
| $P_E$ | 0-0.10 | 0.11-0.25 | >0.25 |
| $P_I$ | 0-0.10 | 0.11-0.25 | >0.25 |
| $P_D$ | 0-0.10 | 0.11-0.20 | >0.20 |
| RWS | 1.0> | 0.90-1.0 | <1.0 |

(Molden and Gates, 1990)

Where
$P_A$ is adequacy, $P_E$ is equity, $P_I$ efficiency, $P_D$ dependability and RWS relative water supply.
Evaluating the values of performance indicators for selected minor (Nagpur minor) requires the crop water requirement ($Et_c$) of dry season crops (i.e. ground nut, sesame, pointed gourd and bitter gourd). Crop water requirement determine on the basis of last five year (2014-2018) rainfall and temperature data, seepage and percolation losses, surface water supply and canal supply data.

**Hargreaves equations**
Crop evapotranspiration estimated using the equation stated by Hargreaves and Samani (1982) and is given as:

$ET_O = 0.0023*R_a (T_M + 17.8)* SQRT (TR)$

Where
$ET_O$ = Reference crop evapotranspiration, (mm/day)
$R_a$ = Extra-terrestrial radiation, (mm/day)
$T_M$ = Daily mean air temperature, (°c)
$T_M = (T_{max} + T_{min})/2$
TR = Difference between daily maximum and minimum air temperature, (°c)

**Crop evapotranspiration ($ET_{crop}$) computed as follows**

$(ET_{crop}) = k_c * ET_O$

Where

$k_c$ = crop coefficient

**Result and Discussion**
**Adequacy**
Adequacy of water delivery is determined at the head regulator of Nagpur minor canal during Rabi season (2018) irrigation supply**.**

**Table 2:** Crop water requirement using Hargreaves equation

| Crops with growing season | $ET_o$ (mm) = 0.0023 * $R_a$ ($T_m$ +17.8) * √TR | $K_C$ | $ET_{crop}$ (mm) = $ET_o$ * $K_c$ |
|---|---|---|---|
| Groundnut (5 Jan – 25 April) | 536.5 | 0.875 | 469.4 |
| Sesame (20 Feb-11 May) | 465.0 | 0.675 | 313.8 |
| Pointed gourd (15 Jan -28 June) | 839.9 | 0.85 | 713.9 |
| Bitter gourd (15 Jan- 29 May) | 705.0 | 0.85 | 599.2 |

**Table 3:** Adequacy of Nagpur minor delivery system

| Total Volume of canal water supplied ($m^3$) | Crops grown | Area under different crops (ha) | Crop water requirement (m) | Flow Volume required at the head regulator of the minor canal ($m^3$) | Adequacy |
|---|---|---|---|---|---|
| 184032 | Groundnut | 79.8 | 0.47 | 375060 | 0.302 |
| | Sesame | 21.5 | 0.3 | 64500 | |
| | Pointed gourd | 17.5 | 0.7 | 122500 | |
| | Bitter gourd | 7.8 | 0.6 | 46800 | |
| | | | Total | 608860 | |

This value of calculated adequacy i.e.0.30 indicates the poor performance of the Nagpur minor irrigation system (Table 3). The low value of adequacy is mainly due to poor water supply of canal system in this season. The delivery of canal irrigation water is considered adequate when irrigation water supply ($Q_D$) is equal to the required irrigation water ($Q_R$).

**Equity**
Equity of Nagpur minor canal system is determined during Rabi season (2018) and shown in Table4. Equity is assumed that the volume of water released has been equally distributed to the crops.

**Table 4:** Equity computation for Nagpur minor system

| Crop | Volume of delivered water ($Q_D$), $m^3$ | Volume of required water ($Q_R$), $m^3$ | ($Q_D$)/($Q_R$) | Mean | Standard Deviation (SD) | Variance = SD/Mean |
|---|---|---|---|---|---|---|
| Groundnut | 46008 | 375060 | 0.122 | 0.548 | 0.377 | 0.687 |
| Sesame | 46008 | 64500 | 0.713 | | | |
| Pointed gourd | 46008 | 122500 | 0.375 | | | |
| Bitter gourd | 46008 | 46800 | 0.983 | | | |

The value of equity of Nagpur minor canal i.e. 0.69 shows the poor equity of the canal. The closer the value of equity to zero, the more equitable the distribution of water is in the system.

**Relative water supply**

The value of relative water supply is determine on the basis of last five year precipitation data, canal supply and crop water requirement data for those four crops. Calculation of relative water supply is presented in Table 5.

**Table 5:** Relative water supply of Nagpur minor canal irrigation system

| Total volume of canal water supplied ($m^3$) | Total rainfall volume during dry season ($m^3$) | Crops Grown | Area under different crops (ha) | Crop water requirement, (m) | Total volume of water required by the crops ($m^3$) | Relative water supply |
|---|---|---|---|---|---|---|
| A | B | | C | D | C*D | (A+B)/∑(C*D) |
| 184032 | 524567.1 | Ground nut | 79.8 | 0.47 | 375060 | 0.726 |
| | | Sesame | 21.5 | 0.3 | 64500 | |
| | | Pointed gourd | 17.5 | 0.7 | 122500 | |
| | | Bitter gourd | 7.8 | 0.6 | 46800 | |
| | | | | Total | 608860 | |
| | | | | Total seepage loss | 367197 | |
| | | | | Total | 976057 | |

From the above Table 5, relative water supply of Nagpur minor canal is calculated as 0.73. From the result obtained, it is clear that there is less quantity of water available at the canal reach. To fulfil the crop demand, more water has to be delivered. The value of RWS greater than or equal to 1 indicates good performance of water distribution system. From the results obtained, it is clear that the water delivery system does not meet the desired requirement of the crops and hence present a poor performance. The canal system is not adequate. The water distribution system is not equitable and the relative water supply is low. The reason of inequity and relative water supply may be attributed to poor water delivery against crop demand in the canal system. Thus, there is need of improvement in the canal performance. This result is further attributed due to most of the canal length as unlined and thereby enormous seepage is encountered.

**Conclusion**

Nagpur minor canal system presents a poor hydraulic performance relating to adequacy, equity and relative water supply indicators. The value of adequacy is 0.30; indicating the poor performance of the canal system. It means water is not delivered in adequate quantity over the different reaches in the canal. The value of equity is 0.69; indicating poor equity and unfair supply of water. The reasons for inequity may be attributed to poor water delivery against crop demand in the canal system. Relative water supply of Nagpur minor canal is 0.73 revealed less quantity of water delivered over the reaches.

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