Impact of Ranbir canal closure on wheat productivity in Jammu district

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Abstract: The aim of the study was to assess the impact of the Ranbir canal closure on wheat productivity which is closed for de-siltation and cleaning purpose for the period of January to Mid-April every year. The study involved the use of pre-tested proforma and the data regarding the effect of Ranbir canal closure on wheat was collected by a recall method from the farmers of three villages namely Kalyanpur, Rambagh and Musa chak of Jammu district in the union territory of Jammu and Kashmir. The results revealed that with the closure of Ranbir canal the total loss in productivity due deficiency in irrigation was to the tune of 13% which accounted for ₹ 19 crore for the whole Ranbir command. The study emphasis that the government and policy makers should take major steps in solving the problem to stop hue and cry of Jammu farmers and more importantly to restrict the annual loss of ₹ 19 crore rupees due to the closure of the canal.

Keywords: crop water requirement, irrigation, Ranbir canal, wheat, yield

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1 Introduction

Wheat (*Triticum aestivum*) is the major source of protein, minerals, B-group vitamins and dietary fibre (Kumar et al., 2011) and one of the important staples of nearly 2.5 billion of world population (Ramadas et al., 2019) ranking it second most important cereal crop in the world after rice (Nazim Ud Dowla et al., 2018). Wheat plays crucial role in ensuring global food security supplying fifth of global food calories and protein (Erenstein et al., 2022). Globally, it is cultivated in an area of 221.84 million ha with a production and productivity of 779.3 million tonnes and 3.5 tonnes ha^{-1} respectively (USDA, 2022). In India, the wheat crop is cultivated in about 31.1 million ha with a production and productivity of 109.59 million tonnes and 3.4 tonnes ha^{-1}, respectively (USDA, 2022) and occupying second place in wheat production after China (Sahu et al., 2020)

In Union territory of Jammu and Kashmir, the wheat crop is grown in an area of 243.75 thousand hectares with production and productivity of 4839 thousand quintals and 1985 kg ha^{-1} respectively (DES, 2021). In Jammu and Kashmir wheat growing areas remained confined to subtropical area of Jammu division, and in valley besides having lot of potential area under wheat cultivation and favorable climatic conditions it is relatively very low (Kour et al., 2012, Wani et al., 2017). In Jammu division, wheat is grown under both irrigated and rain-fed conditions (Kumar et al., 2022) and the area under wheat crop is 242.48 thousand hectares with a production and productivity of 4811 thousand quintals and 2357 kg ha^{-1} (DES, 2021). It is quite less as compared to the national (31.6%) and world (32.8%) productivity. In irrigated belt of Jammu district, rice-wheat is the

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major cropping pattern being followed from time in memorial. The farmers in the irrigated belt normally grow wheat in the month of November and harvest the same in the month of April (Anonymous, 2022), whereas the farmers of Kandi belt usually depend on the rainfall pattern and cultivate the same depending on the availability of moisture through rains. The major source of irrigation to wheat crop in Jammu district is through Ranbir canal system (Anonymous, 2014) and the canal opens from mid-April to end of December and remains closed from January to mid-April for desiltation purposes.

Due to the closure of the Ranbir canal system from January to mid-April, the condition of both rainfed and irrigated belt are the same as both depend on natural rainfall for irrigation of wheat crop. It has been reported that the productivity of wheat declined upto 40% due to change in rainfall pattern (Junagadh Agricultural University, 2017). The percentage of decline in productivity at various stages of wheat growth due to the non-availability of irrigation are as: 35 percent if not given at crop root initiation stage, 20 percent at tillering stage, 20 percent at jointing stage, 25 percent at booting stage, 17 percent at milk stage and 10 percent at dough stage (Junagadh Agricultural University, 2017). The present study was conducted to assess the impact of Ranbir canal closure on the productivity and the financial losses encountered by the farmers in Jammu district of Union territory of Jammu and Kashmir.

2 Materials and methods

2.1 Study location

The present study was conducted in Jammu district of the erstwhile state of Jammu and Kashmir and the district is spread over an area of 2342 km^2 and is located 74°24' and 75°18', East longitude and 32°50' and 33°30' North latitude with an elevation of 300 meter above the sea level with forest covering of 297 km^2 which forms 12.7% of the total area of the district. The annual precipitation is 1200 mm with the bulk of the rainfall in the months from June to September.

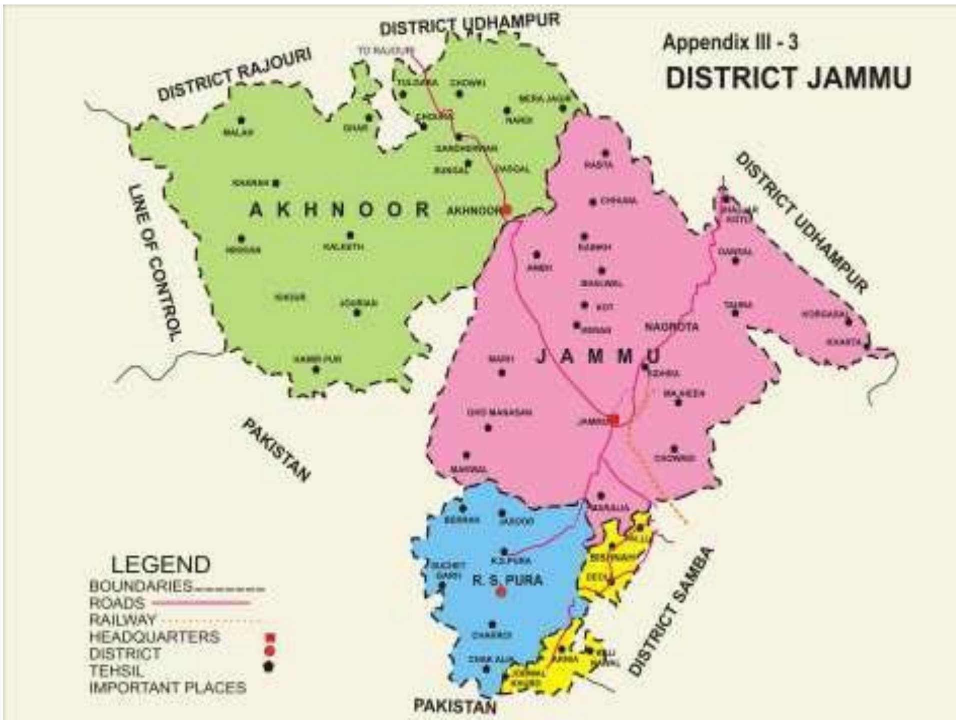

Figure 1 Map of the study area

2.2 Irrigation of the study area

The main rivers of Jammu district are Chenab and Tawi and the water of these rivers are being utilized for irrigation and hydro power generation purposes. In addition to some of the important canals of Jammu district are as Ranbir canal, Pratap canal and Ravi-Tawi irrigation. The respective canals with their command areas are represented in the Table 1.

Table 1 List of irrigation canals with their respective command area

Name of canal	Command area
Ranbir Canal	38800 ha
Pratap canal	5400 ha
Ravi-Tawi irrigation complex	66850 ha

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2.3 Ranbir canal

In Jammu district, the main source of irrigation is Ranbir canal and it takes off from left bank of river Chenab up stream of Akhnoor bridge, which is 25 km North East of Jammu city and passes through four tehsils of the district viz. Jammu, Akhnoor, R.S. Pura, and Bishnah. The canal system has a gross command area of 67000 ha and culturable command area of 38800 ha covering 489 villages (Malothra, 2018). The major source of irrigation for wheat crop in Jammu district is through Ranbir canal system and the canal opens from mid-April to end of December and remains closed from January to mid-April for de-siltation purpose.

2.4 Collection of rainfall data

The rainfall data of the district was collected for a period of 30 years (1980-2010) from All India Coordinated Research Project (AICRP) on Irrigation Water Management SKUAST-J- Chatha Jammu and the data was analyzed for ten years interval period for *Rabi* season so as to find the trend in changing rainfall pattern.

2.5 Estimation of crop water requirement of wheat crop

The water requirement is the total quantity of water required by the crop from the time it is sown to the time it is harvested including application losses. The water requirement of the wheat crop was calculated to estimate excess/deficit rainfall pattern in comparison with the consumptive use (*CU*) of wheat crop by using the equation given below

$$\text{Water requirement(mm)} = \text{Evapotranspiration (mm)} + \text{Efficiencies} + \text{other water use(mm)} \quad (1)$$

The evapotranspiration (ET) is generally taken equal to the consumptive use of the plant which includes the water removed from soil by transpiration and evaporation plus water used by plant for maintenance of its tissue system. Since the quantity of water required by plants to maintain its tissue system is generally one percent of evapotranspiration, hence we take consumptive use approximately equal to the evapotranspiration. The other parameters considered for the estimation of the water requirement are as; crop growing season, effective rainfall, net irrigation requirement, field irrigation requirement and gross irrigation requirement. The evapotranspiration or Consumptive use of the crop was calculated using Modified penman method as the long-term meteorological data which is generally used in calculation of evapotranspiration/consumptive use was not available. The equation used for estimation is as follows (FAO, 1991)

$$ET_c = Kc \times ET_0 \quad (2)$$

Where, ET_c is the crop evapotranspiration (mm day^{-1}), Kc is the crop coefficient, and ET_0 is the reference crop evapotranspiration (mm day^{-1}).

Crop growing season

The time taken by the crop from the time it is sown till harvesting is known as the crop growing season i.e., time taken by the crop from seed to seed.

Effective rainfall (R_e)

The precipitation falling during the growing season of the crops required to meet the evapotranspiration needs of the plant, is called effective rainfall (R_e). The effective rainfall was calculated using following equation.

$$R_e = 0.0011x^2 + 0.4422x \quad (3)$$

Where;

R_e is effective rainfall (mm)

x is nominal rainfall (mm).

Net irrigation requirement (N_i)

It is the amount of irrigation water required in order to meet the evapo-transpiration needs of the crop.

$$N_i = CU - R_e \tag{4}$$

Where;

N_i is Net irrigation requirement (mm)

C_u is consumptive use (mm)

R_e is effective rainfall (mm)

Thus, N_i is the difference between the field capacity and soil moisture content in the root zone before starting irrigation.

Field irrigation requirement (F_i)

It is the ratio of NIR to the water application efficiency (η_a). During the study application efficiency (η_a) of 0.8 was used as most of the farmers in the command area of Ranbir canal have almost level their land and as such application losses have been taken as 20% with application efficiency η_a of 0.8.

$$F_i = \frac{N_i}{n_a} \tag{5}$$

Where;

F_i is Field irrigation requirement (mm)

N_i is Net irrigation requirement (mm)

n_a is the application efficiency

Gross irrigation requirement (G_i)

It is the ratio of the field irrigation requirement (F_i) to the water conveyance efficiency (η_c). During the study the η_c of 0.7 was used as most of the soil of Jammu region are sandy loam (Sharma et al., 2017) and the conveyance losses usually varies from 30% to 40%.

$$G_i = \frac{F_i}{n_c} \tag{6}$$

Where;

G_i is Gross irrigation requirement (mm)

F_i is Field irrigation requirement (mm)

n_c is the conveyance efficiency

2.6 Estimation of crop coefficient

The crop coefficient of various crops has been provided by Food and Agriculture Organization with respect to its crop growing season. The present study was confined to the wheat crop thus only crop coefficient (*Kc*) of wheat crop was considered and is given in as Table 2.

Table 2 Consumptive use or crop coefficient of wheat crop with respect to crop growing season

Crop growing season (%)	0	5	10	15	20	25	30	35	40	45	50	55	60	65	70	75	80	85	90	95	100
Wheat Crop (Kc)	0.08	0.08	0.15	0.19	0.27	0.33	0.40	0.46	0.52	0.58	0.65	0.71	0.77	0.82	0.88	0.90	0.90	0.80	0.70	0.60	0.2

2.7 Collection of the farmer's data

The study was conducted in three villages namely Kalyanpur (Upper section of Ranbir Canal), Rambagh (Mid-section of Ranbir Canal) and Agwan/ Mussa Chak/ Sunder pur (Tail end section of Ranbir Canal) of Jammu district in the UT of J&K. The data regarding the canal closure effect on yield was collected using pre-tested proforma by a combination of recall method and by taking the actual measurements for farmers in the village. In each village 30 farmers (15 with assured irrigation system and another 15 with unassured irrigation system i.e., totally dependent on rainfall) were provided with questionnaires pertaining to losses being incurred by the farmers in wheat crop due to the closure of canal system.

2.8 Estimation of financial losses

To estimate the loss to farmers due to the closure of canal system, average yield of wheat crop having canal and canal plus tube well as a source of irrigation was compared. The yield in quintals by which the farmers having canal are deprived in comparison to the farmer having their own source of irrigation was multiplied with the procuring price of the wheat for an area of 27548 ha to find the total loss due to the closure of canal system in the study area

3 Results and discussion

The results related to various observation during the experimental study are given below.

3.1 Rainfall data analysis

The rainfall data of 30 years on decadal basis of Jammu district was analysed to determine the trend in changing rainfall pattern and the dependency of farmers on canal water for the production of wheat. The decade-wise rainfall scenario of Jammu district is shown in the Figure 2.

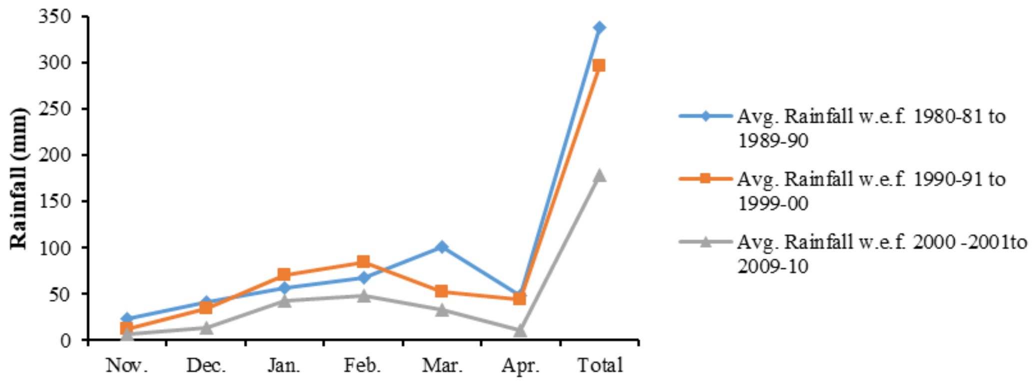

Figure 2 Rainfall scenario of Jammu district for a period of 1980 to 2010

The results revealed that the rainfall in the *Rabi* season in the 1st decade (1981-1990) was 337.8 mm whereas, in the 2nd decade (1991-2000) it remained only 296.1 mm and 190.5 mm in 3rd decade (2001 to 2010). The results indicated a decrease in rainfall by 13% in 2nd decade and 44% in 3rd decade as compared to 1st decade.

3.2 Crop water requirements

The water requirement was estimated on monthly basis using modified penmen method and the estimated crop water requirement of wheat is as shown in Table 3.

Table 3 Crop water requirement of a wheat crop

Month	Mid-Point	Crop grown(%)	K_C	*EP* (mm)	*CU* (mm)	Normal rainfall (mm)	Effective rainfall (mm)	Probability of effective rainfall	NIR	FIR	GIR
Nov 1st-30th	15.0	8.3	0.15	64.0	9.6	15.0	6.8	5.7	3.9	4.8	6.8
Dec 1st -31st	45.5	25.1	0.33	33.0	10.8	30.0	14.2	11.8	-	-	-
Jan 1st-31th	76.5	42.2	0.58	27.0	15.6	60.0	30.4	25.3	-	-	-
Feb 1st-28th	106.0	58.5	0.77	43.0	33.1	70.0	36.3	30.1	3.0	3.7	5.3
Mar 1st-31st	135.5	74.8	0.90	75.0	67.5	76.0	39.9	33.1	34.4	43.0	61.4
Apr 1st-30th	166.0	91.7	0.70	135.0	94.5	40.0	19.4	16.1	78.4	98.0	140.0
Total											213.5

The Table 3 provides the insight of various parameters to calculate the water requirement of wheat crop as explained in section 1.5 previously. From the table it was observed that with increase in percent of crop grown over time results in increase of both evapotranspiration and consumptive due to increase in crop coefficient as observed in Table 2. Subsequently as the consumptive use of crop increases, the plant needs more water to meet its transpiration demands. However, it was observed that these demands are fulfilled by local precipitation only for the months of December and January. Other than that, the crop suffers water deficit to meet the transpiration demands during the crop growing period. More over these irrigation demands may be fulfilled by the Ranbir canal but same remains closed from January to April when the net irrigation requirement is at peak i.e., 3.0, 34.4 and 78.4 for the months of February, March and April. In addition to deficiency of irrigation, the water requirement increases due to losses encountered as a result of application and conveyance losses which accounts for the overall irrigation requirement of 213.5 when gross irrigation of 61.4 cm and 140.0 cm was estimated for the month of March and April, respectively. The total water requirement was estimated to be 213.5 mm calculated on the basis of consumptive use (*CU*) values of 9.6, 10.8, 15.6, 33.1, 67.5, and 94.5 during different stages of the crop's growth period, as indicated in Table 4.

3.3 Estimated consumptive use of wheat crop

The Evapotranspiration of the wheat crop during the study was calculated using Modified penmen method and we take consumptive use approximately equal to the evapotranspiration. Hence the Modified penmen method was used for calculating consumptive use. The estimated consumptive use of wheat crop is shown in the Table 4.

Table 4 Estimated consumptive use of wheat crop

Month	Crop factor (K_c)	Pan evaporation (mm)	CU/ET_c (mm)
1st-30th Nov	0.15	64.0	9.6
1st-31st Dec	0.33	33.0	10.8
1st-31th Jan	0.58	27.0	15.6
1st-28th Feb	0.77	43.0	33.1
1st-31stMar	0.90	75.0	67.5
1st-15th Apr	0.70	135.0	94.5

The crop factor (*Kc*) with respect to its crop growing season was obtained from Food and Agriculture Organization manual and the corresponding pan evaporation was calculated from AICRP on irrigation water management department of the Sher-e-Kashmir University of Agricultural Sciences and Technology of Jammu. In order to estimate the consumptive use (*CU*), Equation 1 was used which is the product of crop factor (K_c) and pan evapotranspiration (ET_0). From the Table 4 it was observed that ET_0 was found to have increasing trend during the crop growing period with the peak values for the months of February to April. Thus, evapotranspiration increases, subsequently the consumptive use of wheat crop increases to meet this increasing demand. The *CU* was found to have higher values after month of January with peak value of 94.5 mm during the month of April. During the same period the canal remains closed for irrigation purpose which in otherwise would have fulfilled this irrigation demand for wheat crop of the study area.

3.4 Consumptive use of wheat crop with respect to rainfall

The consumptive use of wheat crop in comparison to the available water via rainfall is shown in the Table 5.

Table 5 Consumptive use of wheat crop with respect to average rainfall for three decades

Average rainfall on decadal basis	Month						
	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	Total
Avg. rainfall w.e.f. 1980-1981 to 1989-1990 (mm)	23.9	41.0	56.4	67.2	101.4	48.0	337.8
Avg. rainfall w.e.f. 1990-1991 to 1999-2000 (mm)	11.6	34.3	70.3	83.8	52.8	43.5	296.1
Avg. rainfall w.e.f.2000-2001to 2009-2010	6.4	12.9	43.0	47.6	33.5	11.3	179.2
Consumptive use for wheat crop (mm)	9.6	10.8	15.6	33.1	67.5	94.5	231.1

From the Table 5 it was observed that the consumptive use of wheat crop was fulfilled by the average annual rainfall during first decade (1980-1981 to 1989-1990) in all months, while in second decade (1990-1991 to 1999-2000) an average rainfall did not meet the requirement in the months of March and April lacking 14.7 and 51mm but in overall the average rainfall (296.1 mm) was more than the consumptive use of crop (231.1). In case of third decade (2000-2001 to 2009-2010), the water requirement of wheat crop was attained by the rainfall up to the month of Feb but after that there was immense scarcity of rainfall water in the months of March (33.5 against 67.5 mm) and April. In addition to scarcity of water through rainfall and canal closure and the crop being at very crucial stage i.e., milky stage the farmers suffers heavily both in productivity as well as financially.

3.5 Yield of wheat in command of Ranbir canal

The information regarding the yield of wheat crop was collected by face to interview-based questionnaire from farmers under the command area of Ranbir canal and results obtained are shown in Table 6.

Table 6 Yield trend of wheat crop under Ranbir canal command

Village	Source of irrigation	Average yield of Wheat crop (q ha^{-1})			Mean
		1980-1990	1990-2000	2000- 2010	
Kalyanpur	(C+T)	24.5	28.0	27.8	26.8
Rambagh	(C+T)	21.1	25.9	25.0	24.0
Agwan/Sunder Pur	(C+T)	24.7	29.2	28.5	27.5
	Mean	23.4	27.7	27.1	26.1
Kalyanpur	(C)	23.0	26.0	21.5	23.5
Rambagh	(C)	20.5	22.3	20.0	20.9
Agwan/Sunder Pur	(C)	23.5	24.8	21.7	23.3
	Mean	22.3	24.4	21.1	22.6

Note: C+T stands for canal plus tube well as a source of irrigation and C stands for only canal as a source of irrigation.

The data obtained during the study as shown in Table 6 depicts that the yield of wheat crop having canal and tube well as source of irrigation in every study village and each decade was higher than the yield having only Ranbir canal as a source of irrigation which remains close during the peak requirement.

3.6 Wheat productivity reduction due to Ranbir canal closure

To assess the loss of yield to farmers in each village which entirely depend on the Ranbir canal as a source of irrigation a comparison was drawn between farmers having only canal as source of irrigation and the farmers having canal as well as other source i.e., tube well during the closure of the canal. The results obtained are shown in the Table 7.

Table 7 Loss in wheat productivity due to the closure of Ranbir canal

Village	Source of irrigation	Average yield of Wheat crop (q ha^{-1})			Mean
		1980-1990	1990-2000	2000-2010	
Kalyanpur	(C+T)	24.5	28.0	27.8	26.8
	(C)	23.0	26.0	21.5	23.5
Loss (%)		6.3	7.1	22.7	12.0
Rambagh	(C+T)	21.1	25.9	25.0	24.0
	(C)	20.5	22.3	20.0	20.9
Loss (%)		2.9	13.9	20.0	12.3
Agwan/Sunder Pur	(C+T)	24.7	29.2	28.5	27.5
	(C)	23.5	24.8	21.7	23.3
Loss (%)		4.9	15.1	23.9	14.6
Overall Loss (%)		4.7	12.0	22.2	13.0

The results revealed that the losses were found in all the three decades for farmers depending on the canal, but comparatively were less in 1st and 2nd decades than that of the last decade of the study period. The overall losses in 30 years period were found to be 12%, 12.3% and 14.6% for village Kalyanpur, village Rambagh and village Sunder pur respectively with an overall loss of 13.0%.

3.7 Estimation of financial loss due to the closure of canal system

The financial losses to farmers due to the closure of Ranbir canal is represented in the Table 8 and the cost of wheat procurement per quintal was kept Rs.1975 as per the data obtained from the farmers and approved minimum support rice (MSP) of Jammu and Kashmir (MoA, 2021).

Table 8 Estimation of financial loss due to closure of Ranbir canal

Crop	Losses percentage	Yield expected q ha^{-1}	Yield (q ha^{-1})		Rate/q (Rs)	Area (ha)	Losses (crore)
			Obtained	Loss			
Wheat	13.0	26.1	22.6	3.5	1840	38800 (27548)	19.0

It was estimated that the overall loss of 13.0 percent was obtained which accounted for 3.5 q ha^{-1} less as yield compared to the desired production. The total loss of Rs 19 crore was encountered by the farming community due to the closure of the Ranbir canal system during the month of March and April.

4 Conclusion

From the study, it can be concluded that due to the closure of Ranbir canal the farmers face huge problems in respect to productivity as well incurring financial loss. The canal closure amounts to an annual loss of Rs.19 crores from an area of 27,548 ha which is cultivated under wheat crop from the total area of 38,800 ha (71%). These losses can be eliminated by rescheduling the canal closure period and reducing the water deficiency mainly experienced in March and April. Thus, the present study was concluded on a serious note that by all means water must be made available to the farmers in the month of March and April to enhance the wheat production and productivity in the areas irrigated by Ranbir canal.

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