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Impact of Shallow Tube Well Irrigation on Cropping Intensity –A Case Study of Koch Bihar District, West Bengal

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ABSTRACT: The district of Koch Bihar basically has an agrarian economy facilitated by several types of the irrigation system. The shallow tube wells (STW) directly influence on cropping intensity of Koch Bihar District. Its number was 41206 in 2001-02 which increased to 48591 in 2011-12 with an irrigated area of 49957 hectares (ha) to 100379 ha of agricultural land respectively. In 2001-02 its average density was 158 which increase to 168 in 2011-12 per 1000 hectare. The dependency of crop intensity and irrigation intensity found to be increased from 0.087 to 0.17 within 10 years. The figures in totality revealed that the role of STW as a mean of irrigation in this district to be temporally increased.

Keyword: Crop Intensity, Density of STW, Irrigation Intensity. Koch Bihar, Shallow Tube Well.

I. INTRODUCTION

The artificial application of water to soil for the purpose of continuously supplying the moisture essential to plant growth is known as irrigation. It accomplished in different ways by flooding, furrows, spreading, by applying water underneath the land surfaces by sub-irrigation. Six types of irrigation found in the Koch Bihar District. 1. Shallow Tube Well (STW) 2.Deep Tube Well (DTW), 3. River Lift (RLI), 4. Dug Well, and 5. Canal. Among the various sources of irrigation shallow tube well is the most viable and popular irrigation scheme among the farmers of this district

A shallow tube well irrigation system is a procedure in which a long pipe sunk into the ground intercepting and water is lifted with the help of a pumping set operated by an electric motor, diesel or solar engine. A shallow tube well generally 30 meters deep and the diameter of the tube well are range from 80mm to 600mm Shallow Tube Well irrigation is an important indigenous source of irrigation in many countries and is widely used in those areas where irrigation by the canal is not available. Shallow Tube Well (STW) irrigation has contributed to much of the increases in the Net Sown Area (NSA) of the District. In Koch Bihar District, wells are made either by sinking baked earthen ring; about two feet in diameter, in the earth on the top of one another, or else the walls are protected by a square framework of *sal* timber. Sometimes a well is constructed by digging a mere hole in the ground, without any protection to this side [1]. During the 1950s in Koch Bihar 62.26 per cent GIA was under dug wells [2].Well, irrigation was popular during the 19th century. The role of irrigation in West Bengal was brought into perspective only after the attainment of India's independence in 1947 and stress during the 1960's [2].West Bengal accounts for nearly 10 per cent of total STW in West Bengal which is next to U.P, Punjab & Bihar despite the high growth in STW irrigation in the state (4.35 per cent per annum during 1987-88 to 1995-96) [3]. West Bengal is the 4th largest states of India with respect to the number of STW The Royal Commission on Agriculture 1928 was the first to develop into the tube well irrigation system but it was popular in during 1960's in Koch Behar District.

The Koch Bihar District is agricultural based District. But Koch Bihar is an irrigation deficient district. According to Nandini Chatterjee (1995), Koch Bihar belongs to poorly irrigated tract (<10per cent). There is no major irrigation scheme in the district. The depth of water level varies with the topography and become steeper towards the northern side, ranging from 1.17m to 6.7mb,g.l (below ground level).The study area has experienced a considerable drop in their STW water level. Besides, the problems and causes of low utilization of irrigation were not identified as well as their effect on agriculture was not quantified. For the sustainable solution of these problems, a detailed study and research are needed.

The study is carried out to ascertain- 1) To find out the variation of Shallow tube well density in the Koch Bihar District and 2) To find out the impact of Shallow Tube Well irrigation on crop intensity in the District.

II. MATERIALS AND METHODS

Study Area: The Koch Bihar District lies between. 25°57'40"N to 26°32'20"N and 89°54'35"E to 88°47'40"E.(Fig. 1). The Geographical area of the district is 3387sq km with 128 Gram Panchayats and 1202 Mouzas. The average height of Koch Bihar District is 60 msl (above mean sea level). The rivers like the Teesta, Torsa, Jaldhaka, Raidhak, Sankosh, Mansai, along with some minor rivers flow from Himalaya, break suddenly in piedmont area resulting depositing of large amount of boulders, pebbles, gravels, sand, and silt. But in Koch Bihar, the rivers become wide, shallow and braided making an active plain.

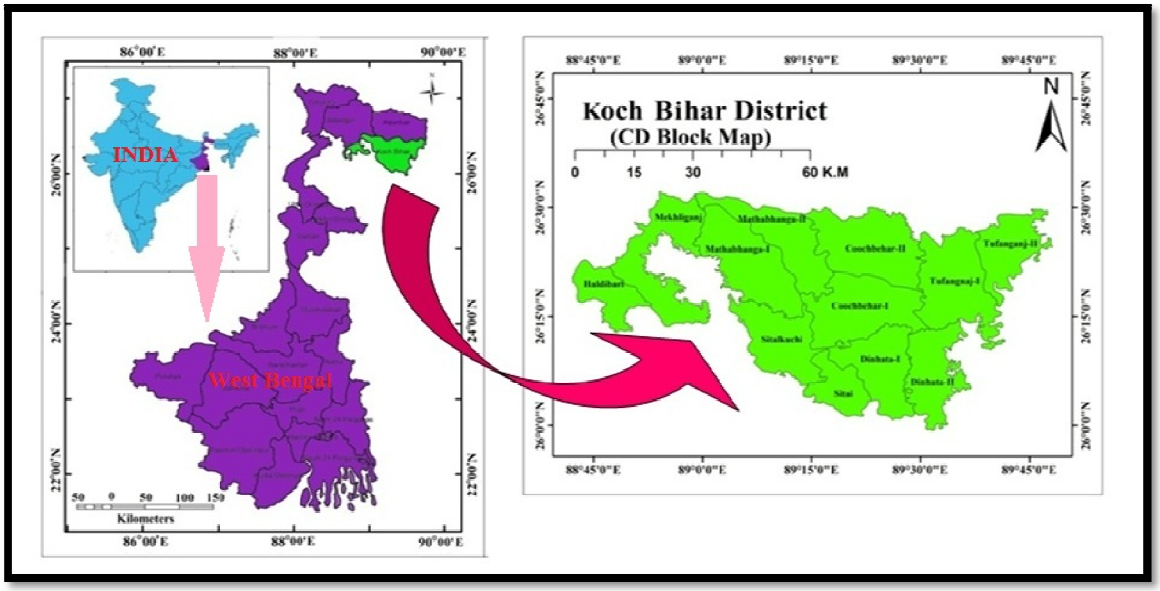

Fig. 1. Location Map of the Study area.

B. Methodology

The study was conducted one-decade *i.e.* 2001-02 to 2011-12. The secondary sources (like Central ground water board, Minor Irrigation Census Report of Koch Bihar, Govt. of India, Central groundwater board, West Bengal, District Statistical Hand Book, Koch Bihar: Bureau of Economics & Statistics Govt. of W.B, District Census handbook, Govt. of India) have been used to collect the data for the present study. Satellite imageries, Google earth, and Bhuban platform etc. were used to generate the maps. The thematic layers were finally integrated using Arc GIS 10.3. Collected data have been presented with different cartographic technique and a statistical method (like Standard deviation, coefficient of variation, Karl Pearson co-relation).The following formulae were used.

1. The density of Shallow tube well (DSTW) was calculated and using the following formula (Minor Irrigation Census, Government of India& Statistical Hand Book, Koch Bihar: Bureau of Economics & Statistics Govt.).

$$\text{DSTW} = \frac{\text{No of STW}}{\text{Net Area Shown}} \times 1000\ Hectar$$

Where, DSTW= Density of Shallow tube well,
STW= Shallow tube well.

2. Blockwise Irrigation intensity (for STW) was calculated using the following formula (Bureau of Applied Economics and Statistics, Govt. of West Bengal.

$$\text{Irrigation Intensity} = \left(\frac{\text{Net irrigated Area of STW}}{\text{Net Cropped Area}}\right) \times 100.$$

3. Blockwise Cropping intensity has been calculated using the following formula (Bureau of Applied Economics and Statistics, Govt. of West Bengal)

Cropping Intensity = (Gross irrigated Area / Net Cropped Area) × 100.

4. The co-efficient of co-relation formulae according to Karl Pearson (1896) has been used to obtain the relationship between irrigation intensity and cropping intensity.

$$r = \frac{\sum xy}{\sqrt{\sum x^2 \times \sum Y^2}}$$

5. Estimation of Variability (CV)

To show the decadal variations of irrigation intensity and crop intensity Coefficient of Variation has been applied. It's a measure of relative dispersions. For each variable, mean and standard deviation values are computed first, from which variability can be found using the following formula –

$$CV = \frac{\sigma}{\mu} \times 100$$

Where,
CV = Coefficient of Variation
σ = Standard Deviation
μ = Mean

III. RESULT AND DISCUSSION

Koch Bihar District become has an agriculture-based economy. According to Irrigation census report, the total geographical area is 3387 sq k.m, with net cultivable area 260768 hectare(ha), Net irrigated area is 165723 ha, Gross crop area (irrigated 201732 ha and un-irrigated 333112 ha), Net sown area is 258737 ha (Koch Bihar District basically has an agrarian economy facilitated by several types of irrigation system. Six types of irrigation found in the Koch Bihar District. 1. Shallow Tube Well (STW) 2. Deep Tube Well (DTW), 3. River Lift (RLI), 4. Dug well, 5. Canal and 6. Tank. Among the various sources of irrigation shallow tube well is the most viable and popular irrigation scheme among the farmers of this district. In 2011-12 the total irrigated area was 85365 ha in which STW irrigation alone share 100379 ha (78.17 per cent), 3106 ha (2.42 per cent) under Dug Well irrigation, 2078 ha (1.62 per cent) under DTW irrigation, 15292 ha (11.92 per cent) under RLI irrigation, 5853 ha (4.56 per cent) under Tank irrigation and rest of 1704 ha (1.33 per cent) under canal irrigation system. [4]. The above facts and figures has been represented in the (Fig. 2). In the Fig. 2 the area of irrigation and the corresponding percentages of each source of irrigation underground water and surfaces irrigation in Koch Bihar District have been given. Observing the area of STW irrigation, the highest percentages were recorded 2011-12.

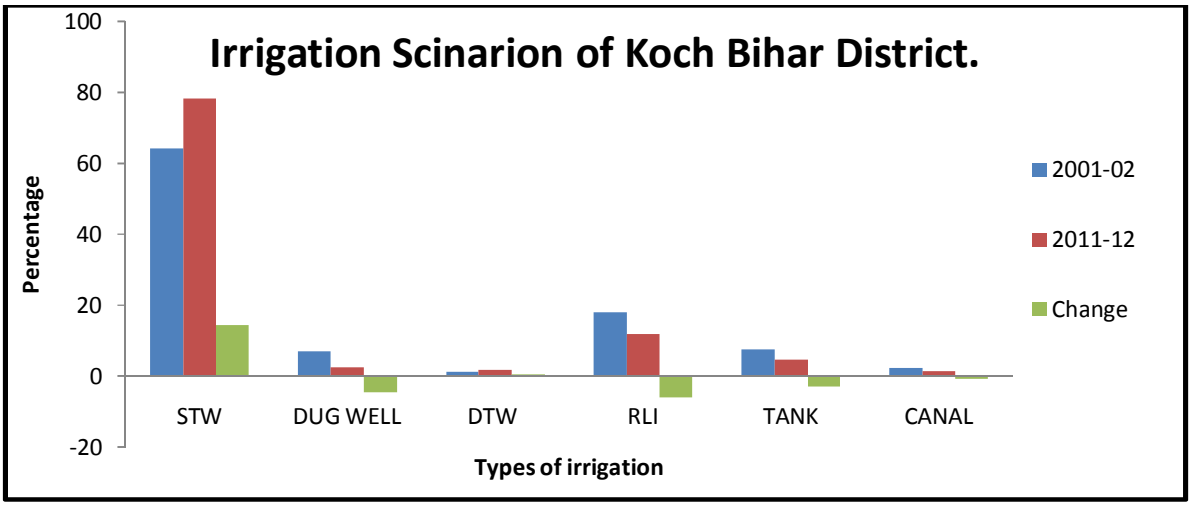

Fig. 2. Irrigation Scenario of Koch Bihar District. (Source: District Statistical Hand Book).

The percentages of STW irrigation in total water resource units has increased 78.17 per cent in 2011-12 from 63.99 per cent 2001-02. In the case of Dug Well, the percentage of Dug Well area into the total area has found to be decreasing 7.03 percent in 2001-02 to 2.42 per cent in 2011-12. In DTW irrigation system the percentage of DTW irrigation system in total water resources has gradually been increasing. During the 2001-02 it was noticed that the irrigated area was 1.26 per cent whereas in 2011-12 it was 1.62 per cent.

In case of RLI irrigation, the percentage of irrigated area was decreasing. During the year 2001-02, it was 17.99 percent whereas in 2011-12 it was 11.92 percent. In the case of TANK irrigation system irrigation area was also found to be decreasing. During the year 2001-02, it was 7.54 per cent was observed whereas in 2011-12 it was 4.56 percent. But in case of Canal irrigation, the area remained same from 2001-02 to 2011-12.

The density of Shallow Tube Well (DSTW): The average density of DTW per 1000 hectare of net sown area in the district is 158 in 2001-02 which is increases to 168 in 2011-12.

The graphs of DSTW of a different block of Koch Bihar shows that only 3 blocks viz. Cooch Behar-I, Dinhata –I, and Mathabhanga II experienced a maximum concentration of DSTW and very poor condition of DSTW are observed in Mekhliganj, Haldibari, and Sitalkuchi and Sitai in 2001-02 (Fig. 3).

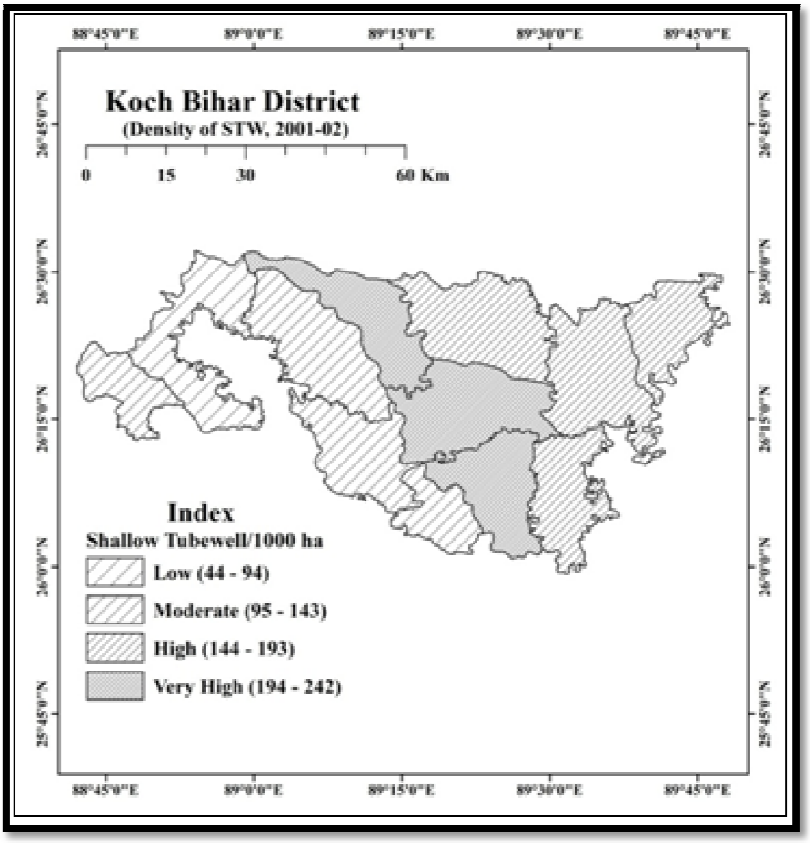

Fig. 3. Density of STW, 2001-02.

The data and map of the density of STW (DSTW) in 2011-12 (Fig. 4) indicate that in Mathabhanga-I, Mekhliganj, Sitai, the DSTW is below 100/1000hectare. The higher DSTW (above 300/1000 hectare) is observed in Haldibari and Mathabhanga and rest of the blocks indicate the DSTW varies between 130 to 269.

From the table and maps it appeared that the DSTW is increasing in Koch Bihar-I, Koch Bihar-II Mathabhanga-II, Haldibari, Mekliganj, Sitalkuchi, Tufanganj – II from 2001-02 to 2011-12 whereas it is decreasing in the rest of the blocks *i.e.* Dinhata-I, Dinhata-II, Tufanganj-I, and Mathabhanga-I (Table 1).

Irrigation intensity and Crop Intensity: The present data has been derived from the information gathered for 10 years i.e. from 2001-02 to 2011-12 from Agricultural Census and District Statistical Hand Book, Koch Bihar: Bureau of Economics & Statistics Govt. of West Bengal.

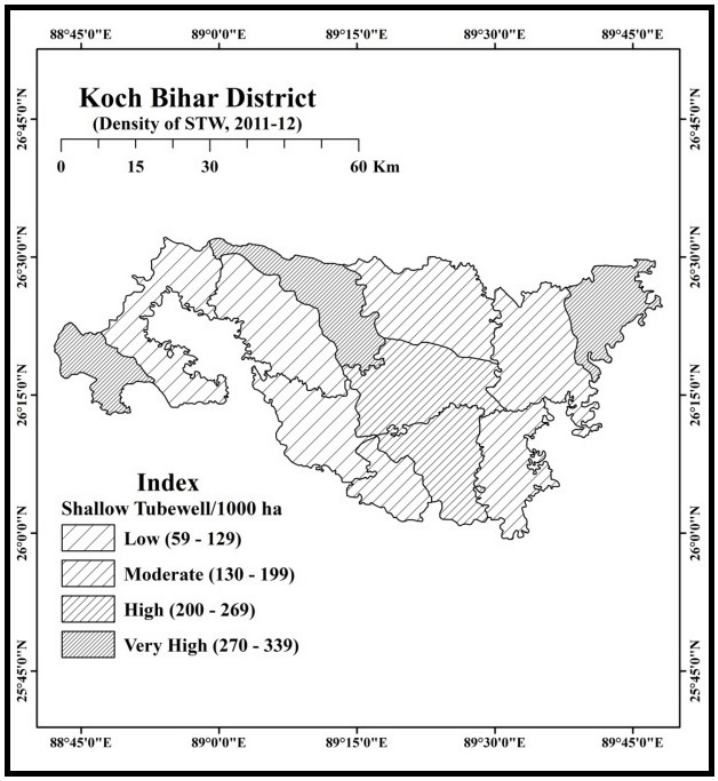

Fig. 4. Density of STW, 2011-12.

Table 1: Density of Shallow Tube Well (DSTW), Koch Bihar, 2001-02 to 2011-12.

Name of The Block	2001-02	2011-12	Change in Per cent
Koch Bihar-I	226	253	11.86
Koch Bihar-II	145	186	28.11
Dinhata - I	242	232	-4.04
Dinhata - II	176	152	-13.81
Haldibari	120	339	183.38
Mathabhanga - I	118	59	-49.67
Mathabhanga - II	240	310	29.10
Mekliganj	44	74	70.33
Sitai	121	132	9.49
Sitalkuchi	118	128	8.47
Tufanganj - I	177	174	-1.55
Tufanganj - II	144	272	89.12
District	158	168	6.33

Source: District Statistical Hand Book, Koch Bihar (2001-02, 2011-12).

The changing pattern of irrigation intensity as well as cropping intensity of Koch Bihar District has been shown for one time period i.e. 2001-02 to 2011-12 (Table 2). Irrigation intensity has increased from 18.93 per cent in 2001-02 to 37.07 in 2011-12. The cropping intensity also increased from 191.22 per cent in 2001-02 to 216.17 in 2011-12, (Fig. 5 & Fig. 6). The maximum positive change of irrigation intensity of STW observed in Tufanganj-II (36.60 per

cent) from 2001-02 to 2011-12. (Fig. 6). In case of cropping intensity the maximum positive and negative change observed in Tufanganj-II (99.61 per cent) and Haldibari (-90.03 per cent) respectively (2001-02 to 2011-12) Fig. 5.

Table 2: Irrigation Intensity of STW and Crop Intensity of Koch Bihar District, 2001-02 to 2011-12.

BLOCK'S NAME	Irrigation Intensity in Percentage		Crop Intensity in Percentage	
	2001-02	2011-12	2001-02	2011-12
Koch Bihar - I	23.19	48.06	172.1	195.86
Koch Bihar - II	15.02	42.6	173.63	180.29
Dinhata - I	40.06	42.01	210.82	203.56
Dinhata - II	20.83	37.45	224.89	185.14
Haldibari	13.82	37.69	223.78	133.75
Mathabhanga - I	9.12	11.67	202.99	201.81
Mathabhanga - II	20.92	48.31	169.42	212.17
Mekliganj	5.07	27.33	166.83	194.15
Sitai	21.59	49.28	214.56	270.76
Sitalkuchi	19.63	47.57	178.23	243.01
Tufanganj - I	23.64	40.38	204.99	207.82
Tufanganj - II	13.61	50.22	185.02	284.63
Mean	18.88	40.21	193.94	209.41
S.D	8.84	11.15	21.98	40.71
C.V	46.84	27.72	11.33	19.44

Source: District Statistical Hand Book, Koch Bihar (2001-02 , 2011).

In 2001, the variability of irrigation intensity was 46.84 per cent which comes down in 2011 (27.72 per cent). So the consistency of irrigation intensity is better with compared to the previous reference year. But the variability of crop intensity in 2001 was 11.33 per cent, whereas in 2011 it reaches at 19.44 per cent. From the table 1 it is clear that irrigation intensity is more consistent in 2011 compared to 2001. But the cropping intensity is less consistence in 2011 compared to 2001.

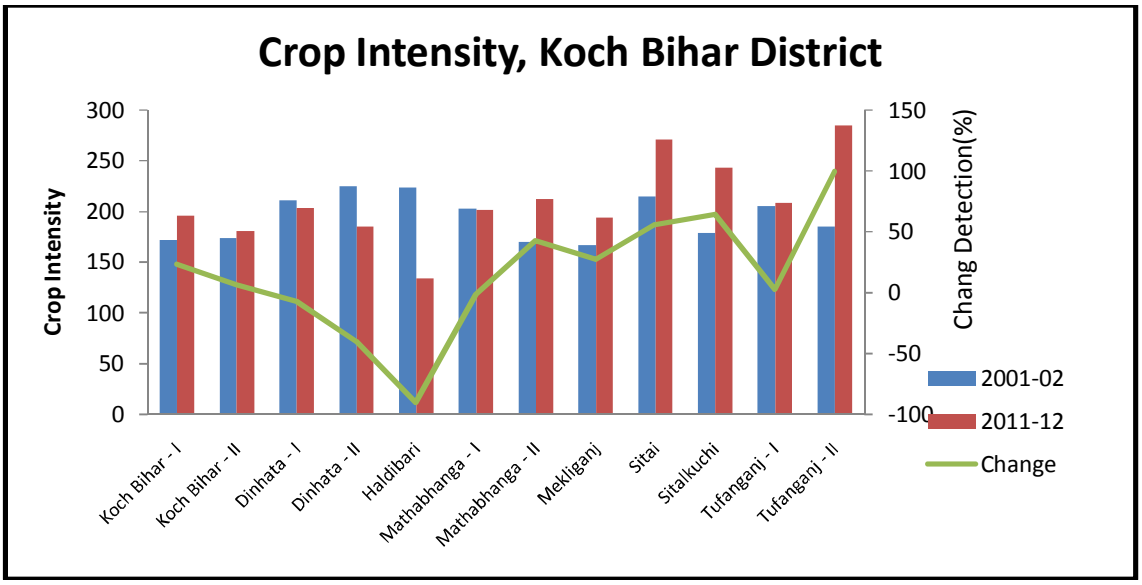

Fig. 5. Crop Intensity, Koch Bihar, 2001-02 to 2011-12.

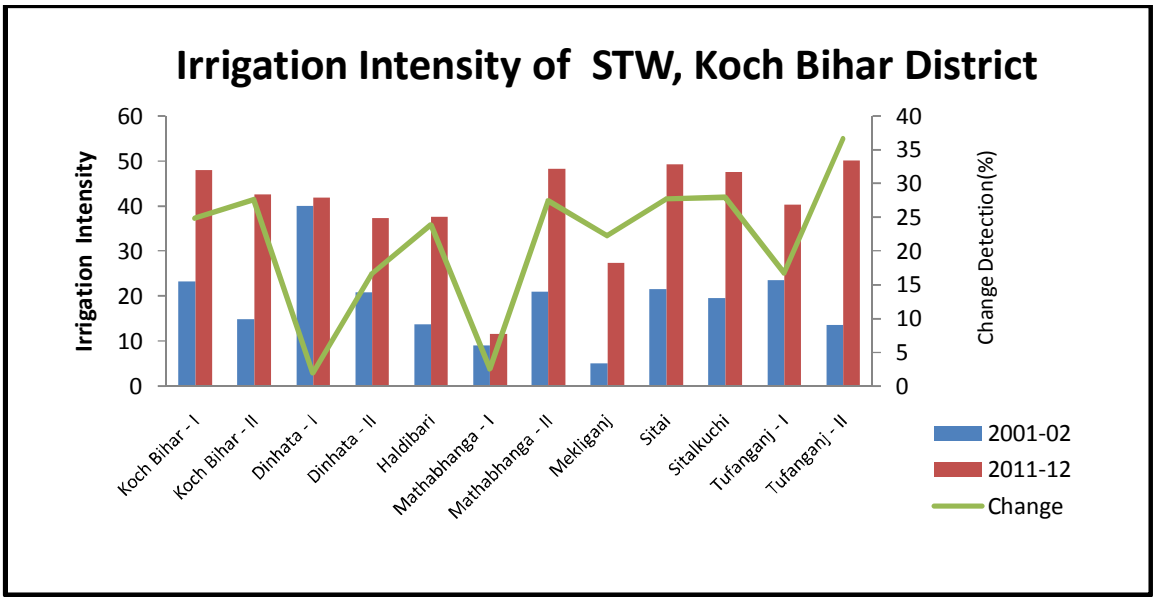

Fig. 6. Irrigation intensity of STW, Koch Bihar District, 2001-02 to 2011-12.

Table 3: Change detection of Irrigation intensity and Crop Intensity, Koch Bihar District.

Name of the Block	Change, 2001-02 to 2011-12	
	Crop intensity	Irrigation Intensity
Koch Bihar - I	23.76	24.867
Koch Bihar - II	6.66	27.585
Dinhata - I	-7.25	1.95
Dinhata - II	-39.74	16.614
Haldibari	-90.03	23.869
Mathabhanga - I	-1.18	2.5523
Mathabhanga - II	42.75	27.39
Mekliganj	27.32	22.26
Sitai	56.2	27.693
Sitalkuchi	64.78	27.941
Tufanganj - I	2.83	16.739
Tufanganj - II	99.61	36.604

Source: District Statistical Hand Book, Koch Bihar, 2001-02 and 2011-12.

The table 3, shows that three blocks *i.e.* (Dinhata-I, Dinhata-II, Haldibari, Mathabhanga-I) have opposite relation *i.e.* increased in irrigation intensity inverses with crop intensity. But rests of the blocks have experience increases in both irrigation intensity and cropping intensity.

The co-efficient of co-relation formulae according to Karl Pearson (1896) has been used to obtain the relationship between irrigation intensity and cropping intensity. The dependency of cropping intensity on irrigation intensity has decreased from 2001-02 to 2011-12 as the correlation of coefficient (r) become 0.295 in 2001-02 (Fig. 8), 0.41 in 2011-12 (Fig. 9). The relationship between irrigation intensity of STW and cropping intensity were trending towards poorly positive. Further, it is also noticed that in 2001-02 about 8 per cent variation of cropping intensity is explained by irrigation intensity of STW as co-efficient of determination (R^2) in this period was 0.087. In 2011-12 the coefficient of determination (R^2) was about 17 per cent variation of cropping intensity were explained by STW. It shows that the dependency of irrigation intensity by STW on cropping intensity is increasing over time.

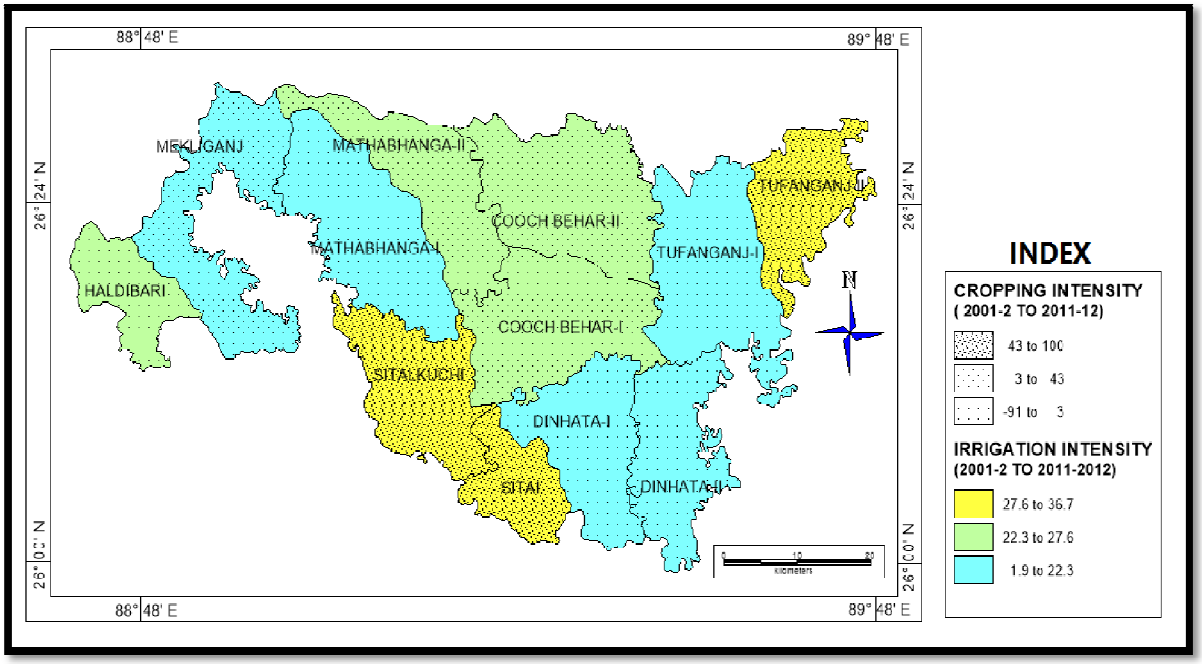

Fig. 7. Relationship between changes in irrigation intensity (STW) and cropping intensity from 2001-02 to 2011-12.

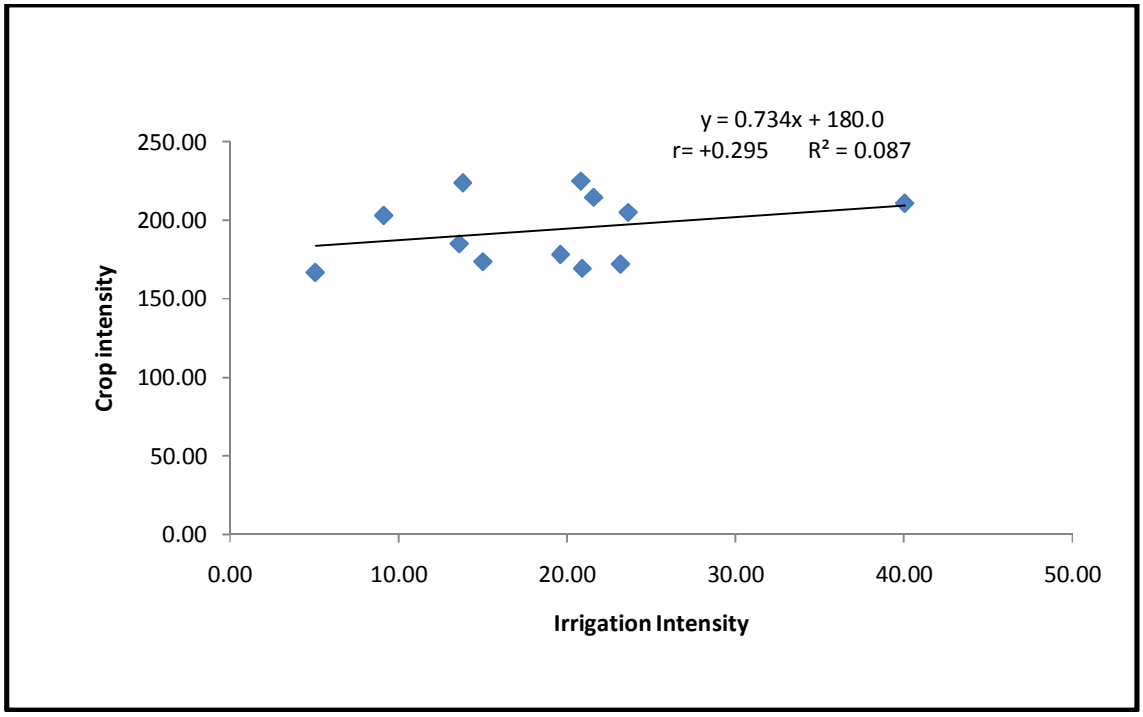

Fig. 8. Block wise relationship between irrigation intensity and cropping intensity, Koch Bihar District (2001-02).

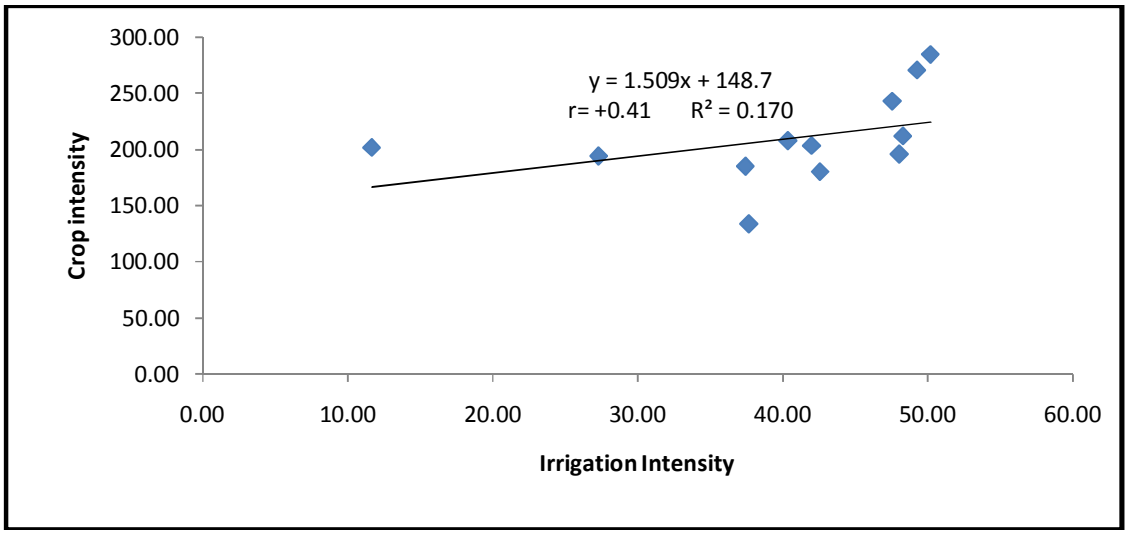

Fig. 9. Block wise relationship between irrigation intensity and cropping intensity, Koch Bihar District (2011-12).

IV.CONCLUSION

The agricultural production and productivity are directly dependent on irrigation. The present study indicates that the STW has a fairly role to play in the annual cropping pattern in Koch Bihar District. The winter crop has it seem to have a significant role as irrigation is to be more intensified during the winter season. The irrigated land of the District is well run by the STW compared to the other irrigation inputs. As such the increasing number and density of the STW shows people's perception on the potentiality of such agricultural device. Hence, the present study further opens up on the role of intensive study on STW in the district.

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