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Cropping intensity, productivity, agricultural development and planning as influenced by integrated water resource management

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Abstract: The land developmental operational works were undertaken in Murshidabad, an agriculturally advanced district of West Bengal (India) during the years between 1984-85 and 2001-02 (seventeen years) with the objectives to develop and manage groundwater resources for effective agricultural planning to increase land under irrigation and crop productivity enhancement. Murshidabad district is one of the potential districts in the agricultural map of the state where diversified crops could be grown in different seasons of the year as the soil, weather and climate permits. Being located centrally in the lower Ganga valley it presents a highly picturesque physical configuration. In fact, the river Bhagirathi has distinctly divided this district into two separate zones viz. 'RARH' and 'BAGRI' depending mainly on its soil types. The western side of river Bhagirathi is known as 'RARH' which is substantially a continuation of the Sub-Vindhyan region of laterite clay and calcareous nodules. The land is high and slightly undulating having a gentle slope from west to east. The soil is comparatively heavy, greyish or reddish in colour mixed with lime and iron-oxide. Uncertainty of rainfall and its uneven distribution without having assured irrigation, most of lands are usually kept fallow after kharif crops harvested. The land conservational measures were undertaken during 2-year period to store excess rainwater through filling up farm ponds and other suitable rainwater harvesting (existing and newly constructed) during rainy season. The results revealed that the cropping intensity increased with increasing of effective irrigation potential as well as net irrigated area with introduction of diversified crops during winter season subsequently grown with stored water. The year round crop planning in accordance with water availability were successively drawn that increased agricultural productivity. Kharif paddy was the main crop in the area wherein the lands were shifted to double and triple cropping with introduction of potato, wheat, mustard and other winter oilseeds and pulse crops during rabi season with incremental irrigation availability including introduction of different vegetable crops under integrated water resource management. There was still enough scope in increasing irrigation potential and possible interventions on integrated water resource management for more precise planning of agricultural development. The benefit of such increasing irrigated area could also able to mitigate the disastrous effect of flood, drought like natural calamities with contingent crop planning.

Key words: Water Resources; Irrigation Potential; Cropping Intensity; Agricultural Productivity and Agricultural Planning.

I. INTRODUCTION

The agriculture, in the study area, is based on mono-cropping wherein the rice during rainy season is predominant crop with suboptimal yield. Vast majority of lands were kept fallow after the *kharif* crops harvested in this area (Anon, 2007). The high yielding varieties of rice still didn't get place due to uncertainty of water availability at crop needs. The eastern part of river Bhagirathi known as 'BAGRI' which is mainly composed of riverine tract of Bhagirathi having light alluvial soil type with comparatively light texture. Hence, importance of land conservational measures on construction of farm ponds, renovation and re-structuring the existing water bodies which could play a important role on multiple use of water also, could enhance the cropping intensities and could increase the agricultural productivity substantially (Zaman, 2012). Hence, the work on operational activities on storage of excess rainwater renovating the existing farm ponds and constructing of new water bodies was carried out in the district in such areas.

II. Materials and Methods

The soil, in the study area, is low in organic carbon content and soil reaction is slightly acidic to neutral. The geo-morphological characteristics and drainage requirement recorded that the district is an alluvial plain and the main river Bhagirathi running from north to south dividing the district into two physiographic units i.e. eastern part is generally flat and western part is an upland slightly undulating. The master slope is gentle from north to south. Geo-morphologically the district can be divided into 4 units (i) Bhagirathi Terrace, (ii) Younger Deltaic Plain, (iii) Older Deltaic Plain and (iv) Lateritic Upland. The major geomorphologic features are mainly three types: (i) channel bar, (ii) palaeochannel and (iii) meander scar. The main drainage system of the district is formed by the Ganga or the Padma with its tributaries are distributaries namely, Bhagirathi, Jalangi, Bhairab, Dwarka, Kuiya, Brahmani and Mayurakshi rivers. The drainage has reached the base level of erosion as a result

of which the activities of the river have lost. The sediment loads carrying by the rivers are being deposited on the bed due to loss of flow velocity, resulting the shifting of river courses as reflected in a number of river scars left in the form of abandoned channels, ox-bow lakes, cut-offs Meander and Swamps in the eastern part of the district.

There are large numbers of beels in the district viz. Hizzole Beel, Beel Baishya, Sagardighi, Ahiran Beel, Bhandardaha Kalantar and Beel Telkar. The Beels are playing a vital role in discharging excess water in rainy season in one hand and in winter season acts as a reservoir of water, which is being utilized for irrigation purpose.

The water table in the district has an elevation ranging from 8-26 m above MSL. In the area east of Bhagirathi river the water table is observed to stand of elevations ranging from 8-22 m above MSL. The gradient of water table is towards river Bhagirathi near Bhagwangola-I and II and Murshidabad-Jiaganj blocks. Ground water is flowing from Raghunathganj block towards Bhagwangola-II block. Water table contour map of the district has given in Fig.1.

The western part of Bhagirathi river tube wells is tapping both confined and unconfined aquifers. The deep tube wells are capable of yielding 150 m³/hr and shallow tube well 30m³/hr for 4m draw down. Transmissivity (T) values ranges from 3000-7000 m²/day except in the northernmost part (in the vicinity of Farakka area, where Transmissivity T) values are much less because of the existence of shallow basement. Storage Co-efficient values ranges from 4.98×10^{-1} to 1.16×10^{-4} indicating unconfined to confined nature of the aquifer.

Spacing of the wells has been determined based on pumping test data for the district. i.e. deep tube well pumping at the rate of 180 m³/hr and shallow tube well pumping at the rate of 3.0 m³/hr, the spacing between the tube well will be 500 m and 125 m respectively.

III. Hydrological framework of the area

Ground water occurs in a thick zone of saturation in the alluvium deposited by Bhagirathi river system. The sand and gravel horizons of different textures constitute main aquifers and occur down to 300 m in the eastern side and 150 m towards western flank of the district.

In the east of Bhagirathi River by and large ground water occurs under water table condition except a few places such as Beldanga block, where ground water condition occurs under local confined condition but it is not regionally extensive. In western part of Bhagirathi river ground water occurs under both unconfined and confined conditions. The flowing condition from shallow tube wells are observed in the eastern part of Bhagirathi near Mirazpur, Jarur (Raghunathganj block). Bilol (Nabogram block) and Dhalsa (Sagardighi block) are in topographical depression and seasonal in nature.

Depth to water level in pre and post-monsoon periods for last ten years reveal that depth to water level in pre-monsoon time rest between 2 and 6 m bgl, but mostly between 4 and 6 m bgl. On the northern and southern parts of the district, west of Bhagirathi River, covering parts of Suti, Raghunathganj and northern part of Bharatpur blocks, the pre-monsoon water level is high, being within 8 m bgl. In post-monsoon (November) depth to water level in major portion lay between 2 and 4 m bgl, except in few places such as 'North western and South Central part, Western part of Baharampur blocks and eastern part of Kandi block where depth to water level is above 6 m bgl.

The major parts of the district water i.e. the central parts covering Khargram, Baharampur, Mur-Jiaganj, Bhagwangola, Raninagar and Jalangi where fluctuation is of the tune of only 0.3 m. In the northern and southern most part of the district, the fluctuations in the ranges of 4-6 m.

IV. Technical Programme

The followings interventions during the year 1984 onward were undertaken as agricultural strategies to get higher crop yield and agricultural productivity:

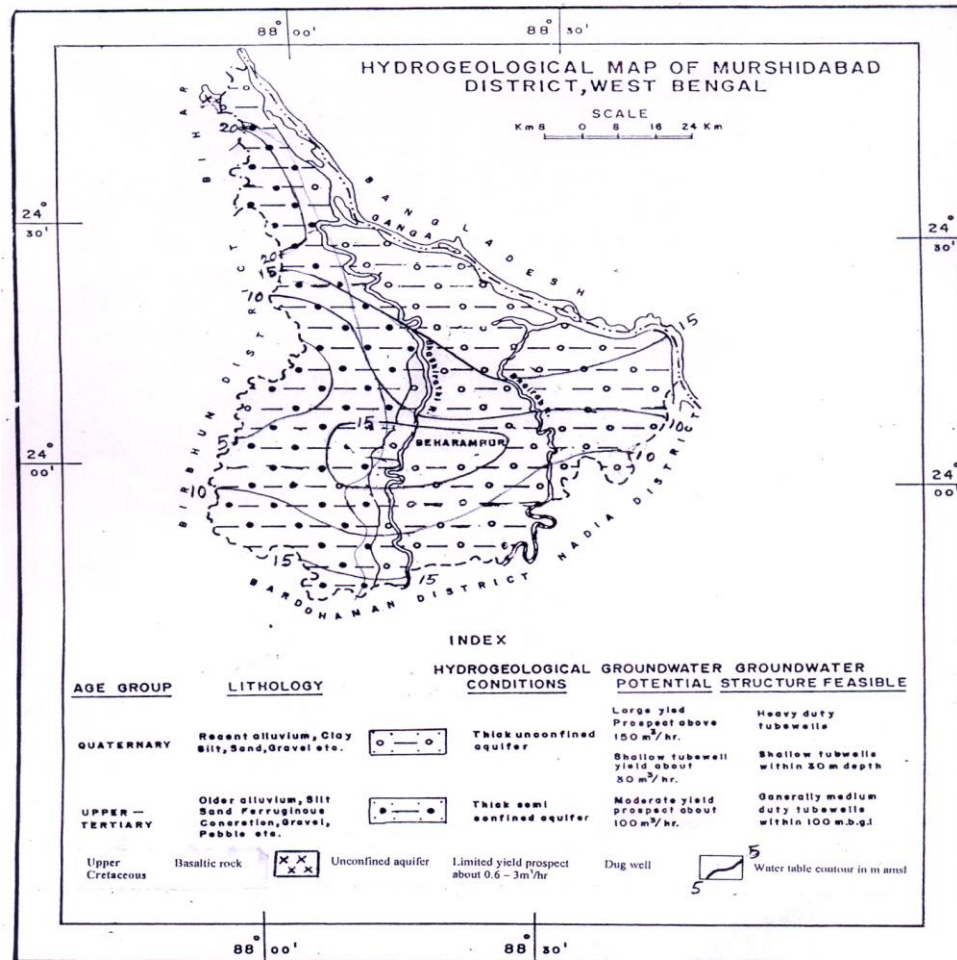
1. Economic use of irrigation water and creation of further irrigation facilities.
2. More application of improved agricultural implements.
3. Adoption of certified seeds along with introduction of high yielding rice varieties.
4. Level for adoption of vegetable hybrid seeds be increased.
5. Application of INM, bio-fertilizers and green manure to maintain soil health.
6. Appropriate measures adopted to protect crops from natural hazards.
7. Dissemination and adoption of latest technology amongst and by the farmers.
8. Effective uses of ground water to obtain more production of crops.

V. Results and Discussion

The role of irrigation is most vital one in the field of agriculture so far as the production of crops is concerned in the district. Further areas of cultivable land will be brought under assured irrigation by creating more numbers of irrigation installations (Anon, 2005).

Natural calamities (i.e. flood/drought) are in common phenomenon in this district every year which affected the agricultural production to a great extent. So, in considering the perspective of that situation more areas under assured irrigation facilities should be increased from all sources (Table 1).

About 62% area under irrigation has been achieved, for which diversified cropping system is followed and as such the cropping intensity had already reached at 220%, but there is still scope for bringing a sizeable area of 15% under irrigation and ground water based irrigation will lead a vital role to create more cultivable area under irrigation. The cropping intensity has direct correlation with the extension of irrigation system created (Table 2). At present, the irrigation potential with all possible interventions increased substantially (Table 3).



Source: CGWB, E.R., Kolkata, West Bengal, India

Fig.1: Hydrogeological map with water table contour of Murshidabad district of West Bengal (India)

Present Ground Water resources (as per GEC-1997 methodology)

Net ground water availability of the district is 218353 ha m. Existing gross ground water draft for all uses like irrigation, domestic and industrial water supply is 172213 ha m. Stage of ground water development in the district is 78.87% which is the highest among 17 districts of the West Bengal State. Allocation for domestic and industrial requirement supply up to next 25 years is calculated as 11628 ha m. Net ground water availability for future irrigation development has been calculated as 10974 ha m. 10 blocks are categorised as 'Safe' and remaining 16 are 'Semi-Critical' Developmental scope in agriculture by ground water. The district already established its importance in the field of agriculture through varied cropping practices and high cropping intensity. To maintain this agricultural status in sustainable manner along with surface water sources ground water has a key role to play. Day by day ground water resources of the district are being increasingly developed for meeting exclusively or as supplementary sources for irrigation. Few parts of the district are severely prone to environmental hazards like flooding. Ground water development may be helpful for stabilizing irrigation during *rabi* season and also for meeting the irrigation demands during *rabi* and post *rabi* period. A modern agricultural management has to take into account for effective water management technique involving economic distribution of water by maintaining minimum pumping hours and also by selecting most suitable cost effective cropping patterns.

VI. Conclusion

The total cultivable land 3, 65,000 ha, which is 68.66% of total geographical area of the district. It has been observed that out of total sources of irrigation water, 33.46% is utilized by surface water and 66.54% by ground water. So, it is vivid that there is a enough scope for irrigation through around water resources. Considering the hydrogeological situation it may be suggested that Low Duty Tube Well (LDTW) is constructed in older alluvium terrain in the western part of the district, where Low Duty Tube Well (LDTW) and Medium Duty Tube Well (MDTW) may be constructed in younger alluvium terrain in the eastern part of the district.

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Table 1: The details of irrigation sources since 1984-85

Source of Irrigation	1984-85	1989-90	1993-94	1998-99	2001-02
Deep Tube Well	424	424	481	562	939 (+MDTW and LDTW)
Shallow Tube Well	30839	37500	45000	73486	74305
River Lift	345	345	364	416	430

Table 2: Cropping Intensity since 1984-85

Year	1984-85	1989-90	1993-94	1997-98	1999-00	2000-01	2001-02
Cropping Intensity	187%	187%	192%	210%	212%	220%	220%

Table 3: Source wise net are under irrigation as below (as on 2001-02)

Sl. No.	Source	Numbers	Under operation	Area under irrigation (ha)
1	Heavy Duty Tube Well	582	498	19980
2	Medium Duty Tube Well	32	25	500
3	Low Duty Tube Well	325	305	907
4	Shallow tube Well (State Owned)	1730	961	1691
5	Shallow Tube Well (Private)	72575	72575	126688
6	River Lift Irrigation	430	376	22560
7	Mayurakshi Canal	-	-	4761
8	Other Sources (Tank, Beel, Nala)	-	-	479955
	Total net irrigated area	225082 (62% on net area under irrigation)		

Table 4: The productions of major crops in the district (2001-02)

Sl. No.	Major Crops	Production th. M ton (2001-02)	Crop yield (t/ha)	
			1984-85	2001-02
1	Aus Paddy	93000	1.2	2.3
2	Aman Paddy	553	0.9	1.4
3	Boro Paddy	385	2.0	4.0
4	Wheat	273	2.5	3.5
5	Jute(Bales)	1722000	1.1	1.5
6	Arhar and Gram	7343	0.4	0.8
7	Rabi Pulses: Mosur	8346		
	Motor	1061	0.3	0.6
	Khesari	4758		
8	Linseed	690	0.3	0.7
9	Mustard	65922	0.3	0.8
10	Til	31	0.4	0.7
11	Maize	4785	1.5	2.5
12	Sugarcane	394872	3.0	10.0
13	Potato	396835	5.0	20.0