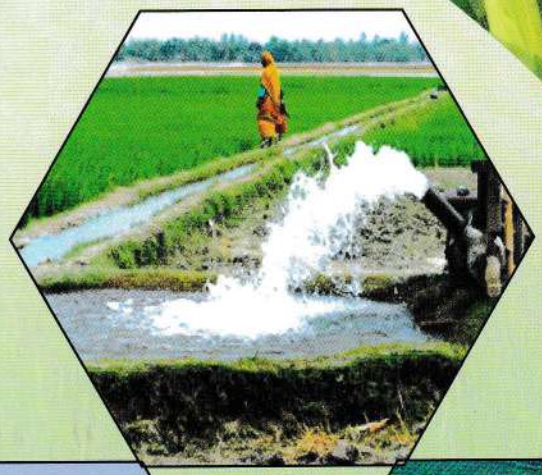
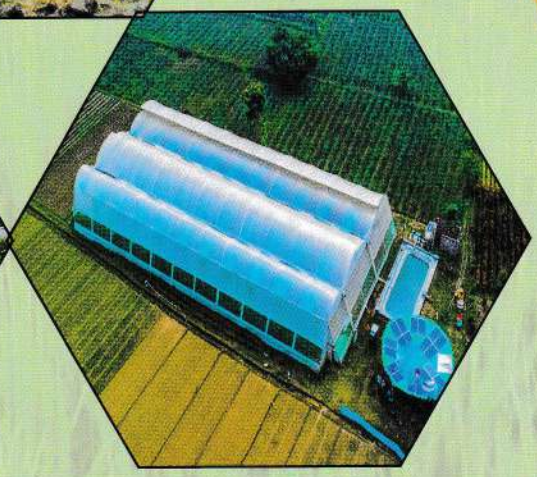
Government of the People's Republic of Bangladesh
Ministry of Agriculture

Minor Irrigation Survey Report 2020-21





Bangladesh Agricultural Development Corporation (BADC)
Digitalization of Survey and Monitoring for Development of Minor Irrigation Project

April, 2022

Government of the People's Republic of Bangladesh
Ministry of Agriculture

Minor Irrigation Survey Report 2020-21
(Rabi Season)

Survey Conducted by

Bangladesh Agricultural Development Corporation (BADC)
Department of Agriculture Extension (DAE)
Barind Multipurpose Development Authority (BMDA)

Report Prepared by

BANGLADESH AGRICULTURAL DEVELOPMENT CORPORATION
Digitalization of Survey & Monitoring for Development of Minor Irrigation Project
22, Manikmia Avenue, Sher-e-Bangla Nagar
Sech-Bhaban, Dhaka-1207

April, 2022

CONTRIBUTORS TO THIS REPORT

Editor	:	Mohammad Zafar Ullah Additional Chief Engineer (MI) Western and Project Director Digitalization of Survey and Monitoring for Development of Minor Irrigation Project, BADC.
Data Validation, Cover Design & Graphics	:	Md. Shoukat Ali Akhand Executive Engineer Digitalization of Survey and Monitoring for Development of Minor Irrigation Project, BADC.
	:	Manira Jahan Executive Engineer, BADC
	:	Mst. Rubina Khatun Executive Engineer, BMDA.
	:	Naznine Khanum
	:	Additional Deputy Director (Inputs), Field Service Wing, DAE.
Data Processing & Compilation	:	Jarinut Tamanna Assistant Engineer Digitalization of Survey and Monitoring for Development of Minor Irrigation Project, BADC
Copy Right	:	Digitalization of Survey and Monitoring for Development of Minor Irrigation Project, BADC.
Publisher	:	Project Director Digitalization of Survey and Monitoring for Development of Minor Irrigation Project 22, Manik Mia Avenue, Sher-e-Bangla Nagar BADC, Sech Bhaban, Dhaka-1207.
Date of Publication	:	April, 2022
Price	:	Tk. 2000.00 Only.

TABLE OF CONTENTS

FOREWORD

Bangladesh Agricultural Development Corporation (BADC) has been successfully working on collecting and monitoring the irrigation and water related data since its inception. Primary data about operation and installation of irrigation equipment necessary for both planning and research work could be found from this report.

It is a great pleasure that Digitalization of Survey and Monitoring for Development of Minor Irrigation Project of BADC is going to publish an informative report on irrigation equipment survey 2020-21. I expect that the report would meet the requirement of some basic information on irrigation which will cover low lift pumps, deep tube wells, shallow tube wells, artesian wells, manually operated pumps, traditional and by gravity flow.

I believe, the findings of the report will help the Government in formulation of policy and taking decisions for effective minor irrigation sub-sector which plays a key role in the production of agri-produces. I also hope that this report will furnish necessary irrigation related data for the planners, researchers and administrators for effective planning in irrigation sub-sector.

I like to extend my thanks to my colleagues of Minor Irrigation Wing of BADC, BMDA and DAE who contributed in preparing and publication of the report.

AFM Hayatullah
Chairman, BADC.

PREFACE

Digitalization of Survey and Monitoring for Development of Minor Irrigation Project is directly involved with collection of data regarding groundwater and surface water monitoring, survey of irrigation equipment & irrigated area, benefited farmers, groundwater level & irrigation water quality, irrigation costs etc. Main objective of this project is to generate reliable and adequate statistical data about minor irrigation development. So, Survey and Monitoring Project has been introduced to make the prevailing monitoring system more widened, consolidated, stronger and modernized as well as to provide technical support and cooperation to the users.

Minor irrigation survey has been being performed by three organizations jointly and the report is published on the basis of the information collected by BADC, BMDA and DAE since Rabi season 2004-05.

I believe that the findings of the report will help the Government in formulation of decisions for effective irrigation planning. I also hope that this report will furnish the planners, researchers and administrators necessary irrigation related data for effective planning in minor irrigation sub-sector.

I would like to extend my sincere thanks to all my colleagues both in the field and at project office for their efforts to publish the report. I am especially grateful to Naznine Khanum, Additional Deputy Director, DAE, Mst. Rubina Khatun, Executive Engineer, BMDA for their sincere efforts in composing this report.

I am very much grateful to Chief Engineers of irrigation wing and also Member Director (MI), BADC for their valuable suggestions for preparing and publication of this report.

Special thanks to AFM Hayatullah, Chairman, BADC, Md. Asadullah, Director General DAE and Md. Abdur Rashid, Executive Director, BMDA for their participation and valuable suggestions to make this effort successful.

Mohammad Zafar Ullah
Additional Chief Engineer (MI) Western
and
Project Director
Digitalization of Survey and Monitoring for Development
of Minor Irrigation Project, BADC.

EXECUTIVE SUMMARY

The main objective of this report was the survey on current agricultural practices by irrigation in **Rabi** season. In **2020-21** Irrigation Season total irrigated area is **5654789** hectares of which **4108254 (72.65%)** hectares are through utilization of groundwater and **1546535 (27.35%)** hectares through utilization of surface water.Currently, Net Cultivable Area in Bangladesh is about **8460950** ha where Total Irrigated Area is **5654789** ha, which is about **66.51%** of Net Cultivable Area. Increased groundwater accessibility resulting from the expansion of deep and shallow tube wells helped Bangladesh to attain near self-sufficiency in rice. Available evidence suggests that the policy focus so far has been largely on "resource development", and not on "resource management". This has resulted in serious problems, most notably excessive drawdown (declined static water level) in intensively irrigated areas and the deterioration of groundwater quality. Increasing energy prices are also threatening the sustainability of irrigation in Bangladesh.

The forefront challenge, therefore, is to take the necessary corrective measures before the problem becomes either insolvable or too costly to remediate. So, attention must be given to the development and management of surface water resources to lessen pressure on groundwater. In addition to supply-side solutions, water demand will also need to be curtailed by increasing water use efficiency through the adoption of water conserving management practices, for example reduced tillage and raised bed planting, improve irrigation water management technology and the right choice of appropriate crops. Decreasing water availability both in terms of quantity and quality suggested that the unchecked expansion of dry season **boro** rice cultivation is probably not a long-term option for Bangladesh. Therefore cropping patterns need to be rationalized considering water availability and the sustainability of aquifers. In the absence of proper institutional arrangements, evaluation of strategic options and monitoring national policies implementation for the public water sector will remain a challenge. At present, seven different agencies are responsible for the management of groundwater resources. In addition to technical solutions, needs a strong linkages and improved communications between different organizations involved in the management of groundwater resources. This report has prepared on the basis of the data/information collected through the survey conducted by three organizations BADC, DAE and BMDA in the **Rabi** season of **2020-21**. The survey has been conducted on **Boro, Wheat, Potato, Maize, Fruits and Vegetables** which has been irrigated by minor irrigation equipment.

Key Messages

1. In the year **2020-21; 36,955** Deep Tube Wells, **14,09,689** Shallow Tube Wells and **2,04,391** Low Lift Pumps are operated in Bangladesh to provide water for minor irrigation. About **72.65%** of the total cultivated area is irrigated by groundwater and the remaining **27.35%** area is irrigated by surface water.

2. About **16,56,113** Nos. of irrigation equipment's are used in irrigation season of which **73.53%** equipment's are operated by diesel engines and about **26.16%** operated by electricity. Despite subsidies on electricity, diesel pumps are preferred by farmers due to low capital cost and mobility ease within small and fragmented farm lands.

3. Improving water use efficiencies through the adoption of resource conserving crop management practices such as alternate wetting and drying (AWD), direct-seeded rice, and bed planting could help in reducing groundwater demand for agriculture. Fixed-irrigation rates, non-availability of water on needed schedules, and lack of technical understanding are the major constraints in the wide scale adoption of AWD in Bangladesh.

4. Groundwater demand for irrigation can also be reduced by rationalizing cropping patterns. Decreasing water availability both in terms of quantity and quality suggest that the unchecked expansion of dry season rice cultivation is probably not a long-term option for Bangladesh.

5. For sustainable groundwater resource management, integrate water users, investments in development water resources and agricultural technologies, irrigation charge by developing pre-paid meter system or crop specific pricing.

6. Facilitate markets for non-rice crops, promotion of alternative cropping patterns, and extra support for farmers making transition to less water demanding crops is needed.

OBJECTIVES OF THE SURVEY

Bangladesh is one of the largest deltaic countries in the world. It has limited fertile agricultural land in relation to its population. There is abundant water in rainy season but limited water in Rabi Season (January to April) when plenty of water is needed for irrigation purpose. Irrigation is the life blood for increasing agricultural production. In Bangladesh minor irrigation plays the vital role to expand irrigated area, increase food production and thereby to help insuring food security of the country. For the formulation of economic policy and plan for agricultural development, adequate and reliable statistical data about the number & types of irrigation equipment (both diesel and electric), irrigated area, benefited farmers are very much essential.

Survey and Monitoring Project of BADC has been carrying out survey of irrigation equipment since its inception in the year 2000. Five survey reports in five consecutive years 2000 to 2004 have been prepared and published by this project alone. But as per direction of MOA the survey is being carried out by BADC, DAE & BMDA jointly from 2005 and now on.

The main objectives of this report are to survey and monitor the minor irrigation equipment operated for irrigation by utilizing diesel and electricity, area of land are irrigated through utilization of surface water & groundwater and farmers are benefited in Rabi season.

The primary objective of the minor irrigation survey 2020-21 is to gather a better knowledge about minor irrigation facilities and to know the present trend and status of minor irrigation system all over the country.

The detail objectives of the minor irrigation survey 2020-21 are outlined as follows:

- To assess the present trend and status of minor irrigation system;
- To assess the present status of diesel & electric driven minor irrigation equipment in terms of numbers & types such as Deep Tube Well, Low Lift Pump & Shallow Tube Well separately and thereby to help estimating the future requirement of diesel and electricity during the next Rabi Season;
- To assess the irrigated area through utilization of surface water and groundwater and the irrigated area (command area) per equipment;
- To find out the incremental utilization of irrigation facilities; irrigated area and benefited farmers;
- To furnish the planner, researchers and administrators necessary irrigation related data for effective planning in irrigation sub-sector;
- To help the Government in formulation of decisions for effective minor irrigation planning which plays a key role in the production of food grains and thereby to help ensuring the food security of the country;
- To develop skill of the officers and staff of survey and monitoring project through training on irrigation survey, preparing survey procedures and methodologies for the purpose of collecting adequate and accurate data on minor irrigation.

INTRODUCTION

For proper utilization of valuable water in irrigation, it is necessary to collect related in formations regarding irrigation systems from the field, prepare data base, GIS maps & report for future use. Necessity of irrigation related information increases day by day for demand based planning in irrigation sub-sector to enhance irrigated area for ensuring sustainable food grain production in the country.

Minor irrigation consists of mechanized, semi-mechanized and non-mechanized systems of irrigation. Low lift pumps, shallow tube wells and deep tube wells are under mechanized irrigation system; manually operated pumps such as hand tube wells, treadle pumps, artesian wells etc, and gravity flow systems are under semi-mechanized irrigation system. Traditional systems such as doans, swing baskets etc come under non-mechanized irrigation systems.

BADC started irrigation activities through utilization of 1555 nos. of Low lift pumps. Later on in 1967-68, Deep Tube Wells were installed for irrigation purposes where surface water was not available. Similarly in 1973-74 Shallow Tube wells were installed for the same purposes. Besides these methods, irrigation activities in some area of the country are performed through Manual & Artesian Well, Traditional Method, and Gravity Flow Method. The summary of irrigation through utilization of surface and groundwater by different modes is shown inTable-1.

Table-1: Summary of Surface water and Groundwater Irrigation by Different Modes during Rabi Season 2020-21

Sl. No.	Mode of irrigation	No. of Equipment	Area Irrigated (ha)	% of Surface water	% of Total Irrigated Area (ha)	Area Irrigated per Equipment (ha)
A.	**Surface water Irrigation by:**					
1	Low lift pump	204391	1287013	83.22%	22.76%	6.30
2	Gravity flow	0	245136	15.85%	4.34%	
3	Traditional method	0	6124	0.40%	0.12%	
4	Solar Pump	2260	8262	0.53%	0.15%	
Sub Total		**206651**	**1546535**	100.00%	**27.35%**	
B.	**Groundwater Irrigation by:**			**% of Ground water**		
1	Deep tube well	36955	1085431	26.42%	19.19%	29.37
2	Shallow tube well	1409689	3006074	73.17%	53.16%	2.13
3	Manual & Artesian well	0	6752	0.16%	0.12%	
4	Solar Pump	2263	8262	0.20%	0.15%	
5	Dug Well	555	1735	0.04%	0.03%	
Sub Total		**1449462**	**4108254**	**100.00%**	**72.65%**	
GRAND TOTAL		**1656113**	**5654789**		**100.00%**	

From Table-1, it is revealed that during the Rabi Season 2020-21, total 1656113 numbers of irrigation equipment's are used for irrigation in the country which is 0.99% higher than that of 2019-20 Rabi season in which 11639311 nos. of irrigation equipment's were operated. On the other hand, irrigated area was 5654789 hectares in Rabi season 2020-21 which is also 0.99% higher than that of 2019-20 Rabi season irrigated area was 5627598 hectares. Out of total 5654789 hectares irrigated area, 5597382 hectares irrigated by DTW, STW & LLP and 57407 hectares irrigated by Manual/Artesian well, traditional method, gravity flow, solar pump and dug well. Out of total 5654789 hectares irrigated area 4108254 hectares through utilization of groundwater i.e., 72.65% of total irrigated area and 1546535 hectares through utilization of surface water i.e., 27.35% of total irrigated area. The historical development of different types of irrigation equipment's in Bangladesh is shown in Figure-1.

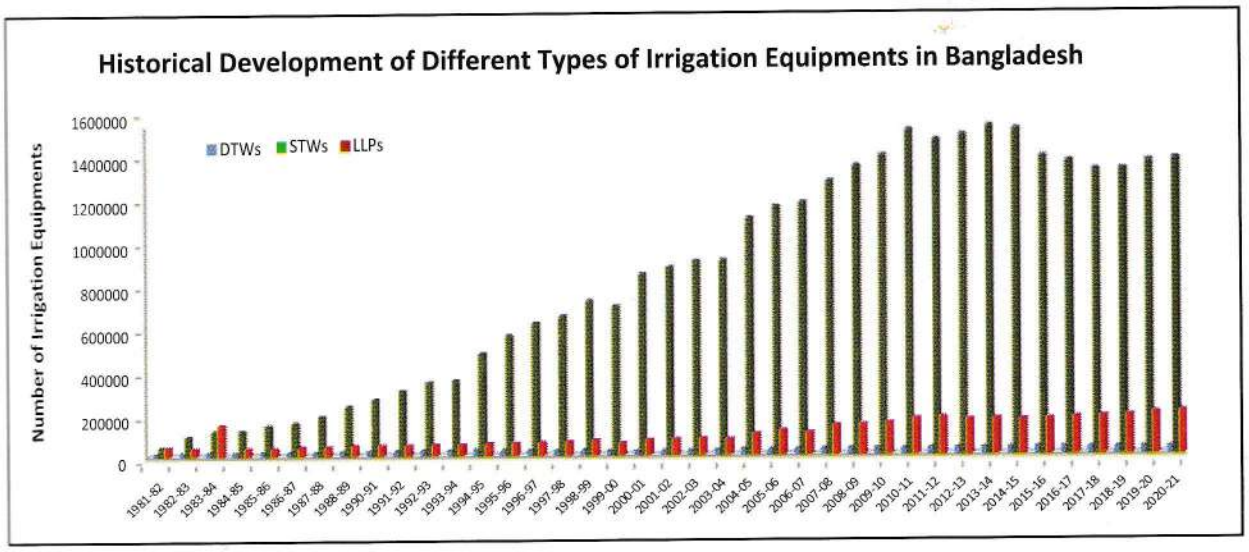


Figure 1: Historical Development of Different Types of Pumps in Bangladesh

With the introduction of high yielding rice varieties in 1980-90s that responded favorably to irrigation and fertilizer, and which are suitable for boro rice, demand for reliable irrigation. Since aquifer conditions were favorable in most parts of the Teesta, Brahmaputra-Jamuna and Ganges River floodplain, the attention was diverted to the development of groundwater resources. The installation of deep tube wells (DTWs) started in the late 1960s, but gained momentum in late 1980s. Within 1992, about 25,500 DTWs were installed throughout the country by BADC. Currently, 36955 DTWs are working in Bangladesh to provide water for irrigation purposes.

The expansion of DTWs was followed by the development of Shallow Tube Wells (STWs) with discharge capacities of 10-20 lit/ sec. However, despite visible benefits of groundwater irrigation, STWs were not initially adopted due to restrictions on tube well spacing and embargo on the import of all types of diesel engines. After devastating floods of 1988 and subsequent cyclones in the early 1990s it is realizing that the need for agricultural machinery to kick-off farming economies back into action.

The government lifted all restrictions and embargos on the import of irrigation equipment. Consequently, local markets were flooded with inexpensive and easy to operate irrigation pumps and small engines (<12 HP), mainly imported from India and China.

The groundwater and surface water irrigated area are shown in Figure-2.

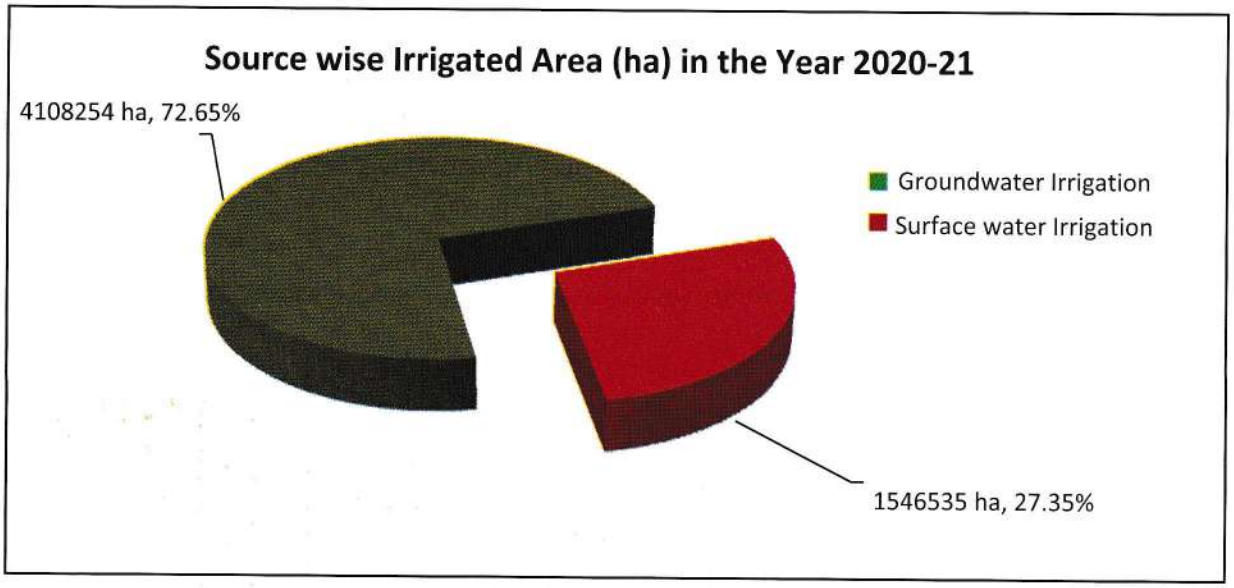


Figure 2: Irrigated Area (ha) of Surface water & Groundwater during Rabi Season 2020-21

Distribution of irrigation equipment's used during Rabi season 2020-21 are shown in the Table-2 and graphical presentation shown in Figure 3.

Table 2: Total Area (ha) Covered by Different Irrigation Mode during Rabi Season 2020-21

Different Mode of Irrigation	Irrigation Year 2020-21	
	Irrigated Area (ha)	% of Total Area
Deep Tube Well	1085431	19.19%
Shallow Tube Well	3006074	53.16%
Low Lift Pump	1287013	22.76%
Gravity Flow	245136	4.34%
Solar Pump	16524	0.29%
Manual & Artesian well	6752	0.12%
Traditional Method	6124	0.11%
Dug Well	1735	0.03%
Total	**5654789**	**100.00%**

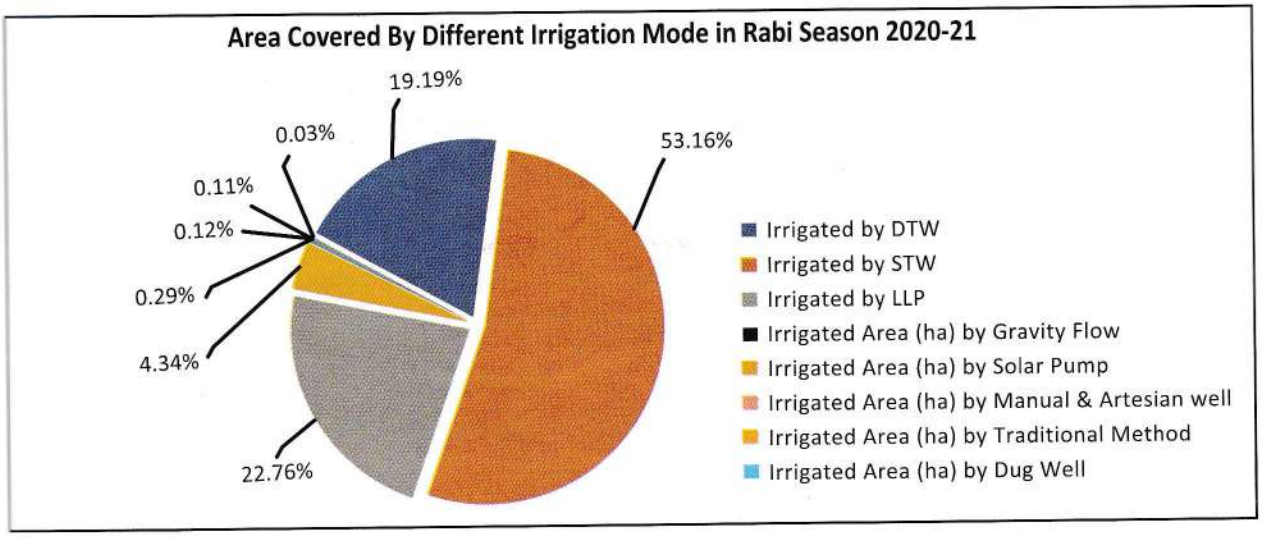


Figure 3: Total Area Covered by Different Irrigation Mode in Rabi Season 2020-21

Distribution of irrigation equipment's used during Rabi season 2020-21 are shown in bellows-

Table 3: Division wise distribution of irrigation equipment's (DTW, STW, LLP) used during Rabi Season 2020-21

Name of Division	Nos. of Irrigation equipment's in the Year 2020-21				
	DTW	STW	LLP	Solar	Dug Well
Dhaka	2570	172778	25727	345	35
Mymensingh	4292	154506	12326	140	42
Rajshahi	17053	302263	12054	389	342
Rangpur	8133	393273	2206	765	89
Chittagong	2054	75826	46245	461	13
Khulna	2640	282805	35970	611	16
Sylhet	212	28079	43607	172	10
Barisal	1	159	26256	1640	8
Total	**36955**	**1406989**	**204391**	**4523**	**555**

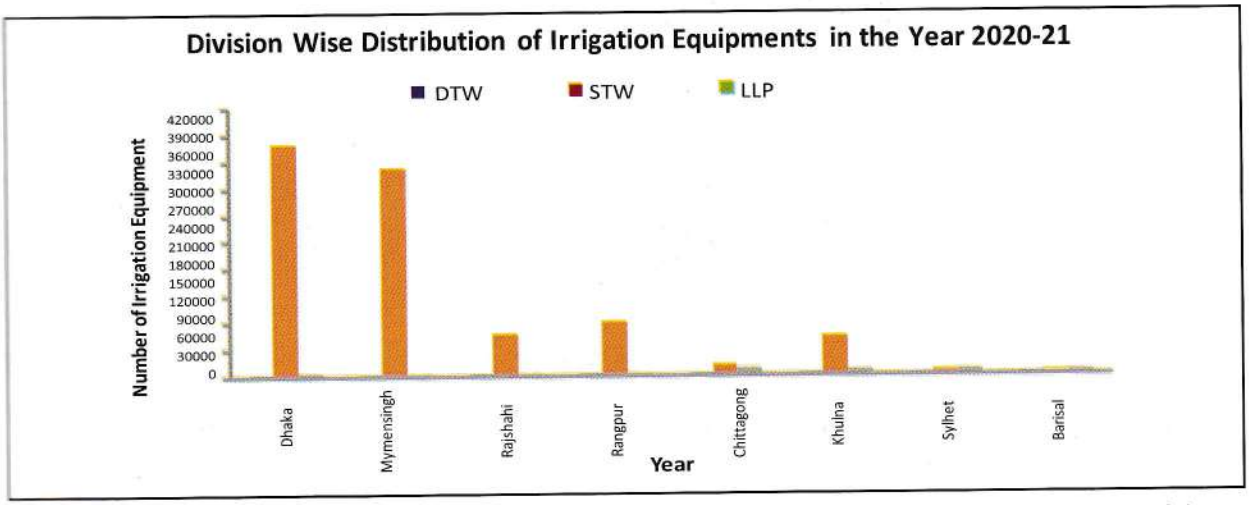


Figure 4: Division wise Distribution of Irrigation Equipment's in the Year 2020-21

Table 4: Division wise distribution of Total Irrigated Area (ha) during Rabi Season 2020-21

Name of Division	Irrigation Year 2020-21	
	Irrigated Area (ha)	% of Total Area
Dhaka	696697	12.32%
Mymensingh	609570	10.78%
Rajshahi	1233277	21.82%
Rangpur	1067345	18.88%
Chittagong	645100	11.41%
Khulna	790412	13.98%
Sylhet	425203	7.52%
Barisal	185460	3.28%
Total	**5653054**	**100.00%**

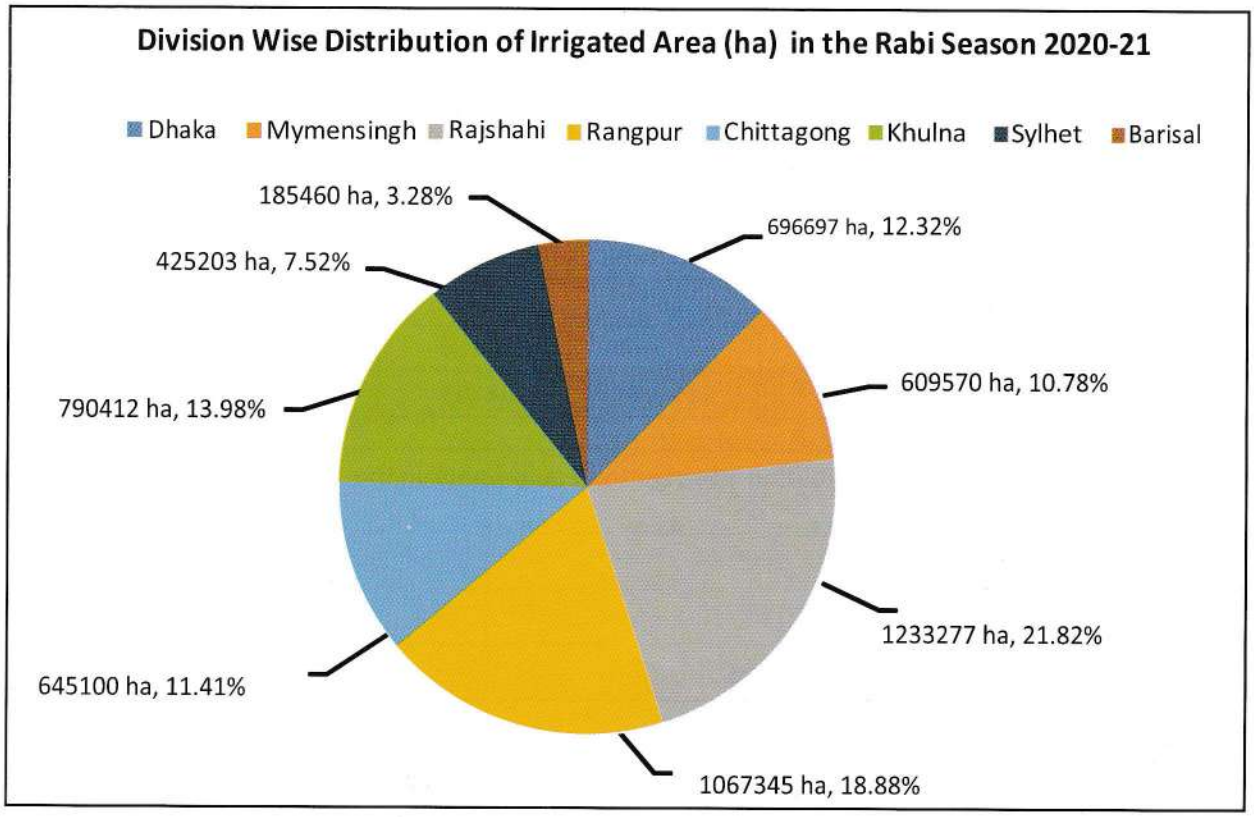


Figure 5: Division wise Distribution of Irrigated Area (ha) in Rabi Season 2020-21

GROUNDWATER IRRIGATION

About 75.42% of the total groundwater is used in four divisions in the North-Central and North-Western hydrological zones i.e., Dhaka, Mymensingh, Rajshahi and Rangpur. In the North West, groundwater irrigation is likely to continue until the limits of land or sustainable groundwater withdrawals are reached. Dry season groundwater irrigation over a seven-month period depends on adequate recharge in the five-month monsoon period. If recharge is not more or at least equivalent to discharge, round the year irrigation will accelerate groundwater depletion resulting in an excessive decline in water levels. On the other hand, it is found that groundwater recharge is higher in the North-west than the South and North-east, respectively, a function of increased groundwater extraction in the former zones.

Farmers of these regions have already started switching to more profitable and less water-intensive crops such as maize, wheat. About **73.53%** of the pumps within Bangladesh are run by diesel engines. The remaining **26.16%** use electricity. Diesel pumps usually have higher costs and lower water extraction capacity than electric. But despite subsidies on electricity, diesel pumps are preferred by farmers due to low capital costs and mobility ease within small and fragmented farm lands. Increasing power cuts and the generally poor electricity network in many rural areas comprise other potential reasons for farmers' diesel pump preferences. In addition to irrigate their own lands, the owners of STWs also provide irrigation services to their neighbors for a fixed seasonal fee in cash or through payment by producing crops.

Groundwater irrigation requires large amounts of energy to lift water from underlying aquifers. In the Rabi season **2020-21** about **35,059** DTWs are electrified; the rest **1896** are diesel operated. Out of the **1.409 million** STWs in Bangladesh, only **0.37 million** are electrified where as the remaining **1031464** are diesel operated. In the North-west, diesel operated STWs are used primarily for irrigating Bororice, and partially for supplementary irrigation to Amanand Ausrice and other crops.

As the genetic and agronomic scope for yield increase in rice is limited, increasing irrigation costs will reduce farmers' net incomes, further threatening the economic foundations upon which boro rice production is based. The following are pictures of some deep tube wells and shallow tube wells:

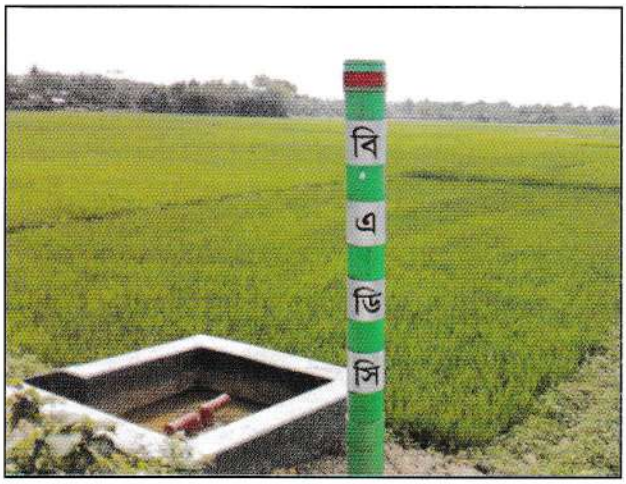


Figure 6: Electrically Operated Deep Tube Well and Buried Pipe Line.

Figure 7: BMDA DTW in Taraganj, Rangpur Upazila

Figure 8: BMDA DTW in Paba, Rajshahi

Figure9: BMDA Solar Energised Dug Well in Shapahar Upazila

Figure10: Solar Operated Dug Well, Godkhali,Jessore.

Figure 11: Diesel Operated STW

During the **Rabi** season **2020-2021,** DTWs and STWs covered throughout the country were 1085431 and **3006074** hectares. In the previous **Rabi** season **2019-20,** total **1084245** nos. of DTWs and STWs were in operation and **1409689** hectares land were irrigated. Deep Tube Well contributed **19.19%** and Shallow Tube Well is contributed **53.16%** of the total area irrigated during **Rabi** season **2020-2021.** Division wise Irrigation by DTWs STWs is shown in **Table-4** along with graphical representation in **Figure10.**

Table-4: Area Irrigated by DTWs and STWs in eight divisions of Bangladesh in Rabi season 2020-2021.

Name of Division	Irrigation Year 2020-2021		
	Area Irrigated (ha) by DTW	Area Irrigated (ha) by STW	Total Irrigated Area (ha)
Dhaka	64619	396321	460940
Mymensingh	148861	333590	482451
Rajshahi	509482	650195	1159677
Rangpur	239160	789196	1028356
Chittagong	54309	206642	260951
Khulna	62155	537584	599739
Sylhet	6825	92142	98967
Barisal	20	404	424
Total	**1085431**	**1409689**	**2495120**

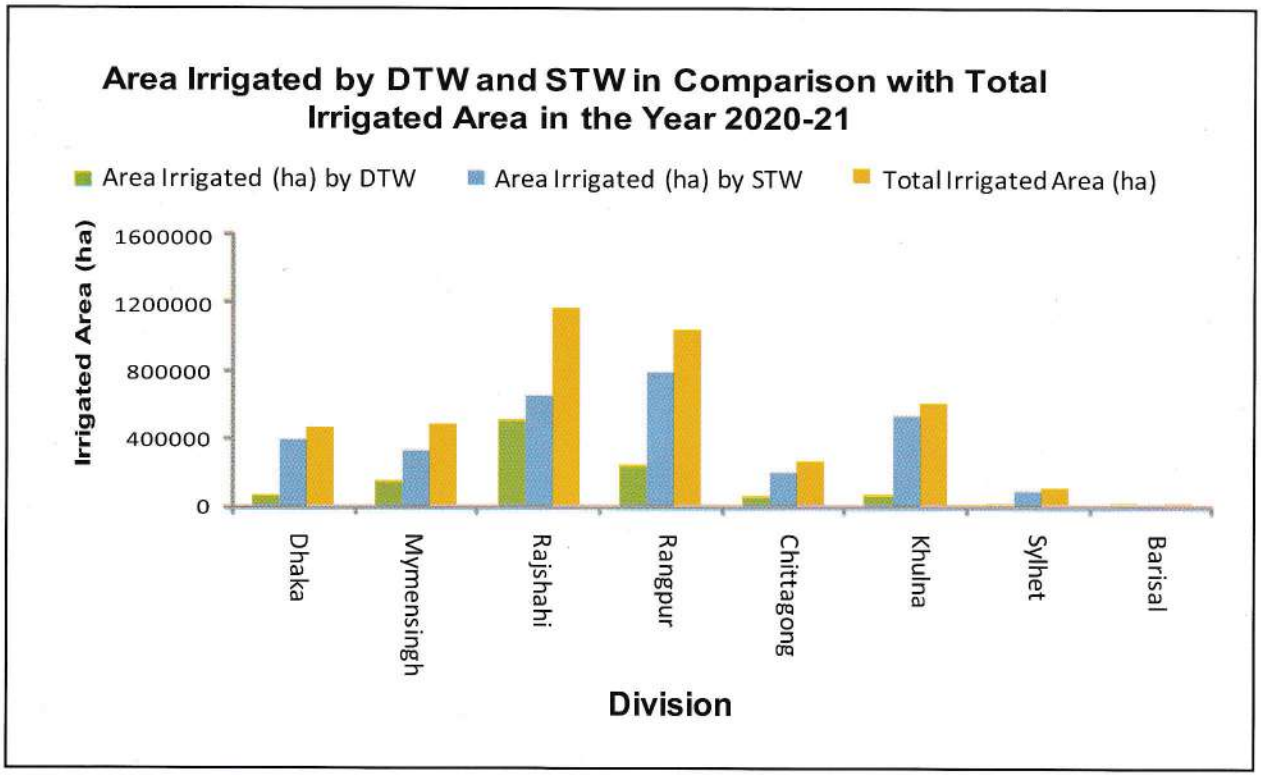


Figure 12: Area irrigated by DTWs and STWs in Comparison with Total Irrigated Area in Rabi season 2020-21

MANUAL & ARTESIAN WELL

Figure 13: Diaphragm Pump

Figure 14: Treadle Pump

Manual irrigation systems are easy to handle, require no technical equipment and are therefore generally cheap. But these types of pumps need high labor inputs. A common and very simple technique for manual irrigation is Treadle pump, Diaphragm Pump, and Hand Pump etc. for groundwater-based irrigation.

Figure15: Artesian Well, BADC

Figure 16: Artesian Well, Private

Artesian well

A **water table** higher than the well ensures water pressure will consistently force water into the well. An **artesian aquifer** is an underground layer which holds **groundwater** under pressure. This causes the water level in the well to rise to a point where the pressure is equal to the weight of water putting it under pressure. Water may even reach the ground surface if the natural pressure is high enough, in which case the well is called a **flowing artesian well**. An aquifer is a **geologic** layer which can hold water such as sand and gravel, **limestone,** or **sandstone,** through which water flows and is stored. An **artesian aquifer**is trapped between rocks or clay which causes the pressure. Water returns to the aquifers when the **water table** at its recharge zone is at a higher **elevation** than the head of the **well.**

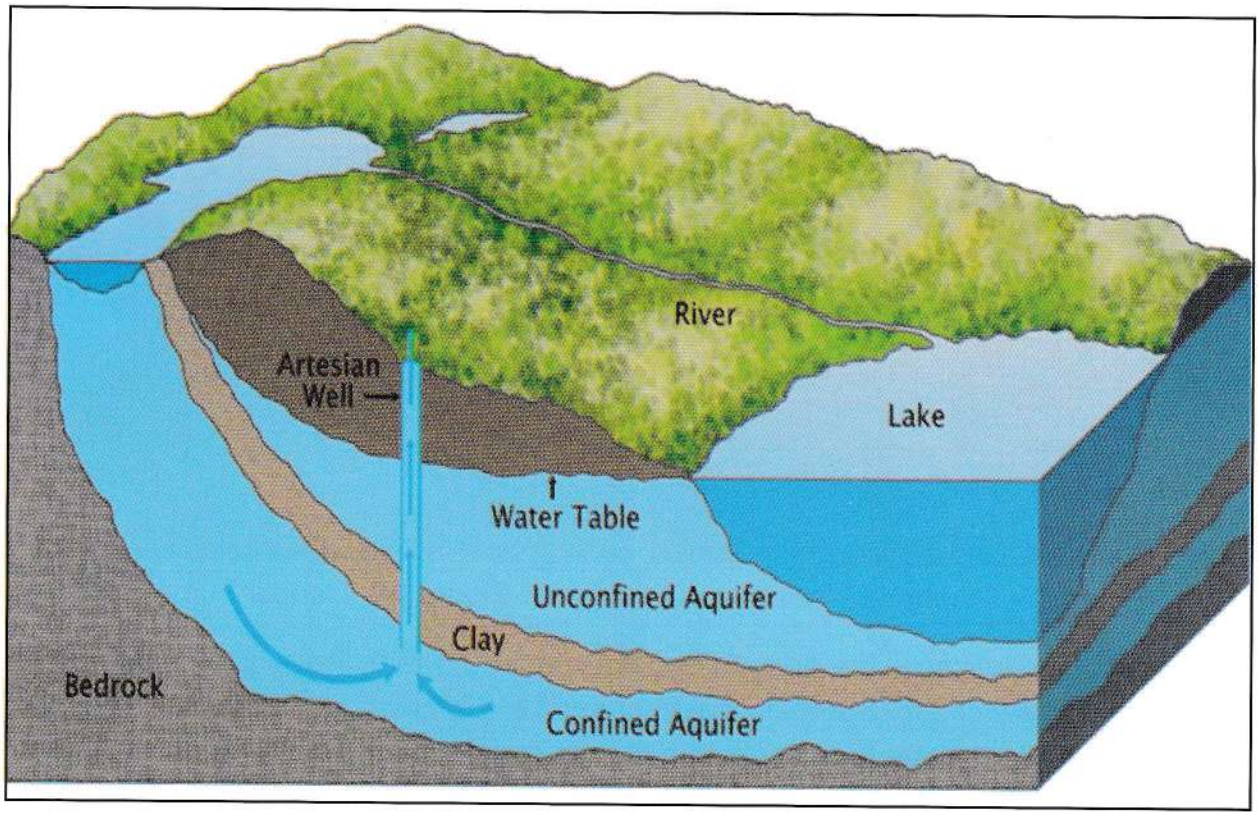


Figure 17: An Artesian Well in Artesian Aquifer.

Division wise irrigated area by Manual and Artesian well method in Rabi season 2020-2021 are shown in the Table-5.

Table5: Irrigated Area by Manual Method & Artesian Well in 2020-2021.

Sl. No.	Division	Irrigated Area (ha)	% of Total
1	Dhaka	1119	14.25%
2	Mymensingh	305	3.88%
3	Rajshahi	230	2.93%
4	Rangpur	200	2.55%
5	Chittagong	810	10.32%
6	Khulna	770	9.81%
7	Sylhet	2570	32.73%
8	Barisal	748	9.53%
Total		**6752**	**100.00%**

SURFACE WATER IRRIGATION

Figure 18: Hydraulic Elevated Dam in Anowara, Chottogram.

Figure 19: Michhakhali Rubber Dam, Bishambhampur, Sunamganj.

Figure 20: 5 Cusec capacities Solar LLP in Sunamganj Sadar Upazila, Sunamganj.

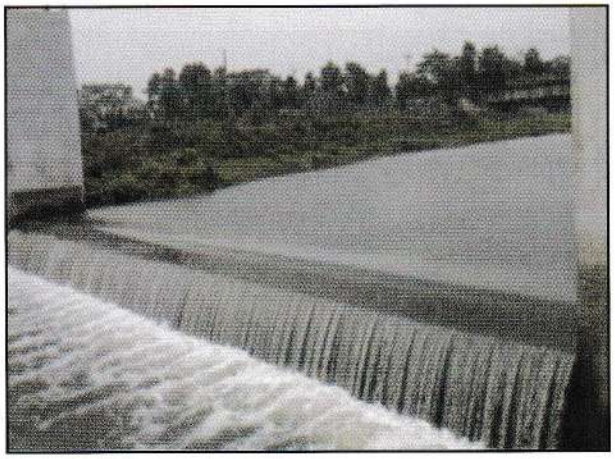
Figure 21: Chellakhali Rubber Dam, Nalitabari, Sherpur.

Figure 22: Chilai River Rubber Dam Doyarabazar Sunamganj

Figure 23: Intake Point Sluice Gate, B. Baria

Figure 24: Submerged Weir, B. Baria

Figure 25: RCC Channel of Habiganj



26: Falimari Khal Badarganj, Rangpur

Low Lift Pumps (LLP):

In **2020-21**, about **204391** nos. of LLP was operated for irrigation purpose and **1287013** hectares area irrigated which is **22.76%** of total irrigated area. Out of **204391** LLPs, BADC operated **8531** nos. of LLPs under various projects through which **208288** hectares of land was irrigated. Division wise no. of LLPs and irrigated area in Rabi season **2020-21** are shown in **Table-6.**

Figure 27: 0.5 Cusec capacities Solar LLP in Dhamrai Upazila, Dhaka.

Gravitational Flow:

In some part of the country irrigation carried out by gravity flow through major irrigation projects. This type of irrigation projects mainly implemented and operated by BWDB. Some of the irrigated areas under gravity flow also covered by BADC, LGED and private sector. It has been observed that during 2020-2021 irrigation seasons, 245136 hectares of land were irrigated by gravity flow method. Division wise irrigated area (ha) by Gravity Flow is shown in the Table-6.

Figure 28: 12.5 Cusec Floating Pump, Shariotpur

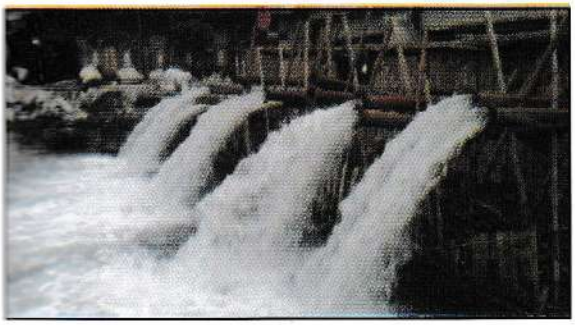


Figure 29: 5 Cusec LLP,Chadpur .

Figure 30: Portable Distribution System in Lalmonirhat Char.

Traditional Irrigation Equipment:

Bangladesh was dependent on traditional means of irrigation, up to 1950s, when irrigation was applied by swing basket, shewty, doan etc. Swing basket or shewty is capable of lifting water up to 3 feet approximately and doans up to 5 feet. After introducing modern irrigation technology, the use of traditional method irrigation is decreasing day by day. During Rabi Season **2020-21, 6124** hectares of land has been irrigated by traditional method. Division wise irrigated area (ha) by Traditional Method in the Boro Season is shown in the **Table-6.**

Figure 31: Don

Figure 32: Portable Solar LLP at Rangpur Char

Figure 33: Different Types of Traditional Irrigation Methods

Table-6: **Area irrigated by Surface water in eight divisions of Bangladesh in Rabi season 2020-21**

Name of Division	Irrigated Area (ha) by LLP	Irrigated Area (ha) by Traditional Method	Irrigated Area (ha) by Gravity Flow	Irrigated Area (ha) by Solar	Total Irrigated Area (ha)
Dhaka	215601	16289	1595	1153	234638
Mymensingh	105870	19782	580	572	126804
Rajshahi	69742	2047	80	1501	73370
Rangpur	20975	14770	270	2774	38789
Chittagong	313172	67132	1672	1423	383399
Khulna	137787	49256	757	2130	189930
Sylhet	248682	73585	820	579	323666
Barisal	175184	2275	410	6419	184288
Total	**1287013**	**245136**	**6124**	**16524**	**1554797**

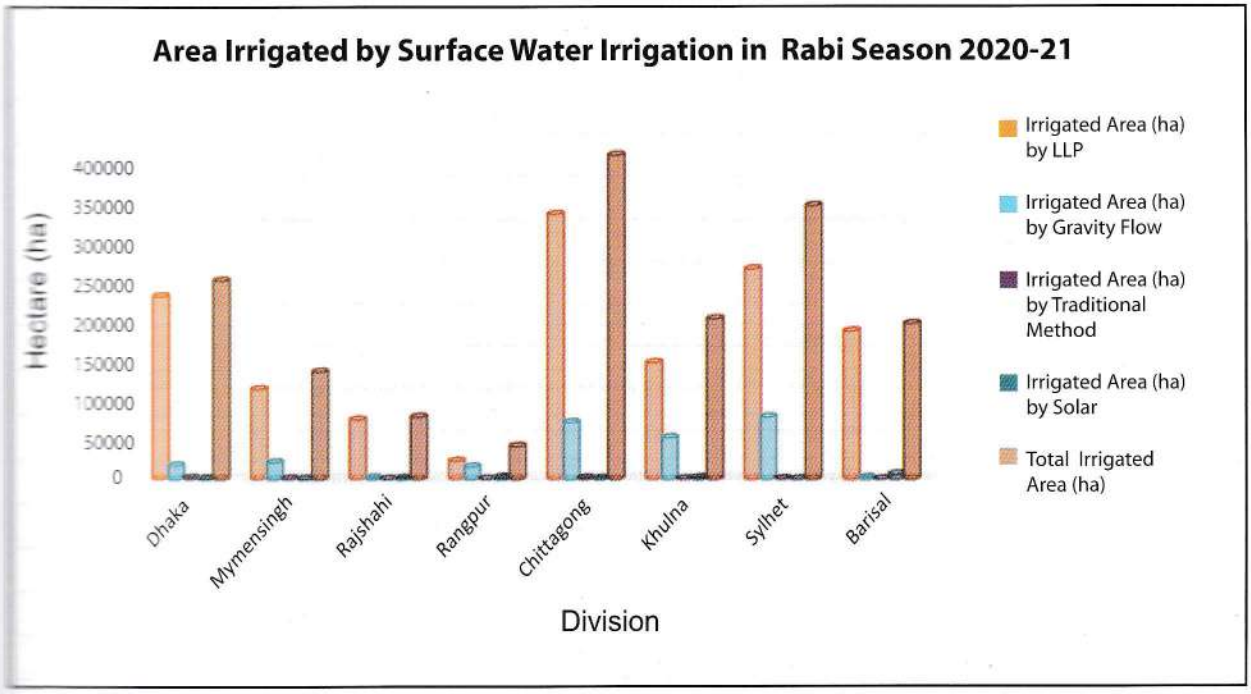


Figure 34: Division wise Area Irrigated (ha) by Surface Water during Boro Season 2020-21

TREND OF MINOR IRRIGATION

A. Operational Equipment and Irrigated Area

The trend of operational irrigation equipment and irrigated area from 1961-62 to 2020-2021 is shown in **Table-7 and Table-8.**

Table-7: Trend of Minor Irrigation Equipment 1961-62 to 2020-2021:

Boro Season	Boro Season Annual Operating(Nos.)			Equipment Annual Change in Percentage(%)		
	DTW	STW	LLP	DTW	STW	LLP
1961-62			1555			0.00
1962-63			2024			30.16
1963-64			2477			22.38
1964-65			2239			-9.61
1965-66			3420			52.75
1966-67			3990			16.67
1967-68	102		6558	0.00		64.36
1968-69	380		10852	272.55		65.48
1969-70	980		17846	157.89		64.45
1970-71	796		24483	-18.78		37.19
1971-72	906		24243	13.82		-0.98
1972-73	1237		32917	36.53		35.78
1973-74	1494	998	35243	20.78	0.00	7.07
1974-75	2699	1029	35534	80.66	3.11	0.83
1975-76	3828	2162	36382	41.83	110.11	2.39
1976-77	4461	3045	28361	16.54	40.84	-22.05
1977-78	7453	6447	36730	67.07	111.72	29.51
1978-79	9329	8379	35895	25.17	29.97	-2.27
1979-80	9795	11280	37389	5.00	34.62	4.16
1980-81	10131	20931	35951	3.43	85.56	-3.85
1981-82	11491	42955	41153	13.42	105.22	14.47
1982-83	13800	93100	35500	20.09	116.74	-13.74
1983-84	15500	120300	36000	12.32	29.22	1.41
1984-85	16900	147000	37000	9.03	22.19	2.78
1985-86	17900	146900	37500	5.92	-0.07	1.35
1986-87	18700	160300	40600	4.47	9.12	8.27
1987-88	20300	188700	42300	8.56	17.72	4.19
1988-89	22400	235900	50800	10.34	25.01	20.09
1989-90	22600	260000	51000	0.89	10.22	0.39
1990-91	21500	270300	51600	-4.87	3.96	1.18
1991-92	25500	309300	50300	18.60	14.43	-2.52
1992-93	25700	348900	52200	0.78	12.80	3.78

Boro Season	Boro Season Annual Operating(Nos.)			Equipment Annual Change in Percentage(%)		
	DTW	STW	LLP	DTW	STW	LLP
1993-94	24500	359200	52600	-4.67	2.95	0.77
1994-95	26700	488900	57100	8.98	36.11	8.56
1995-96	27300	571200	60600	2.25	16.83	6.13
1996-97	25200	629800	62900	-7.69	10.26	3.80
1997-98	25300	664700	66300	0.40	5.54	5.41
1998-99	26700	736100	72900	5.53	10.74	9.95
1999-00	23530	707570	58050	-11.87	-3.88	-20.37
2000-01	23180	865210	71310	-1.49	22.28	22.84
2001-02	23000	893360	77000	-0.78	3.25	7.98
2002-03	23430	924020	79870	1.87	3.43	3.73
2003-04	24720	925150	77790	5.51	0.12	-2.60
2004-05	27180	1128990	99250	9.95	22.03	27.59
2005-06	28280	1182520	119130	4.05	4.74	20.03
2006-07	29170	1202720	107290	3.15	1.71	-9.94
2007-08	31300	1304970	138630	7.30	8.50	29.21
2008-09	32170	1374580	146790	2.78	5.33	5.89
2009-10	32910	1425140	150610	2.30	3.68	2.60
2010-11	33670	1549150	173670	2.31	8.70	15.31
2011-12	34050	1498390	177220	1.13	-3.28	2.04
2012-13	35320	1523610	170570	3.73	1.68	-3.75
2013-14	36034	1563791	171041	2.02	2.64	0.28
2014-15	36566	1549711	167175	1.48	-0.90	-2.26
2015-16	36979	1417008	173179	1.16	-9.36	3.46
2016-17	37175	1398960	176478	0.53	-1.27	1.90
2017-18	37538	1355852	181469	0.98	-3.08	2.83
2018-19	37634	1357532	187188	0.26	0.12	3.15
2019-20	37007	1398706	199914	-1.67	3.03	6.80
2020-21	36955	1409689	204391	0.14	-0.79	-2.24

Note: Data from 1961-62 to 1981-82 Taken from Year wise Progress Report of BADC, data from 1982-83 to 1999-2000 taken from Census of Irrigation in Bangladesh by ATIA Project and data from 2000-01 to 2020-21 taken from Minor Irrigation Survey Report of BADC.

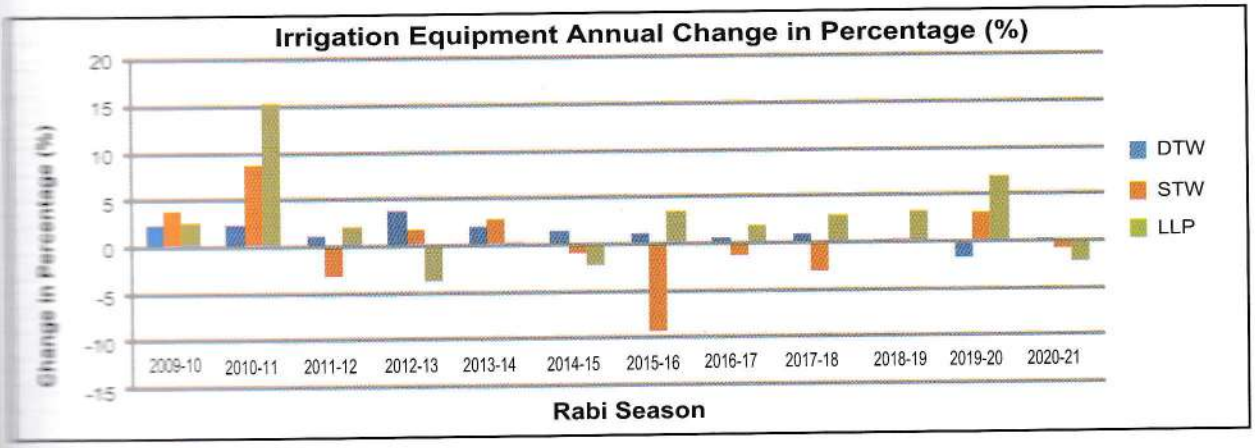


Figure 35: Trend of Minor Irrigation Equipment Change in Percentage of Last Ten Rabi Seasons (2009 to 2021)

Table 8: Trend of Irrigated Area by Different Minor Irrigation Mode (1961-62 to 2020-21):

(Area in Hectare)

Irrigation Season	DTW	STW	LLP	Manual & Artesian Well	Traditional Method	Gravity Flow Method	Solar Pump	Dug Well	Total
1961 -62			29927.9						
1962 -63			5386 3.6						
1963 -64			63461.9						
1964 -65			53547.4						
1965 -66			70247.8						
1966 -67			91135.6						
1967 -68	1667		130373						
1968 -69	6510		180620						
1969 -70	13004		273227						
1970 -71	12984		373230						
1971 -72	11874		369745						
1972 -73	15287		508715						
1973 -74	24881	1806	565477						
1974 -75	47716	2726	576963						
1975 -76	62246	5220	603425						
1976 -77	66477	7168	519479						
1977 -78	137034	27929	708959						
1978 -79	204186	35827	820470						
1979 -80	235748	55400	894775						
1980 -81	259557	99029	912099						
1981 -82	323152	202180	1089873						
1982 -83	234000	371000	337000	16000	405000	160000			1523000
1983 -84	263000	480000	342000	16000	372000	136000			1610000
1984 -85	287000	586000	351000	16000	384000	147000			1772000
1985 -86	304000	586000	356000	16000	314000	163000			1739000
1986 -87	318000	639000	386000	16000	326000	155000			1840000
1987 -88	345000	753000	402000	16000	433000	115000			2064000
1988 -89	380000	941000	482000	16000	391000	170000			2380000
1989 -90	384000	1037000	484000	16000	478000	176000			2575000
1990 -91	365000	1078000	513000	18000	498000	316000			2645000
1991 -92	434000	1234000	500000	19000	316000	251000			2674000
1992 -93	437000	1392000	496000	22000	323000	291000			2829000
1993 -94	389000	1388000	458000	29000	348000	326000			2767000
1994 -95	502000	1638000	538000	25000	250000	352000			3107000
1995 -96	540000	2004000	568000	51000	207000	355000			3752000
1996 -97	475000	2159000	570000	38000	186000	333000			3762000
1997 -98	465000	2182000	622000	64000	201000	285000			3833000
1998 -99	507000	2522000	628000	101000	232000	358000			4349000
1999 -00	529640	2122510	581800	18650	76520	227400			3556520
2000 -01	538260	2295660	603280	6530	71730	250850			3766310
2001 -02	530290	23550 30	628750	7460	36900	286010			3849770
2002 -03	587930	2409410	664020	11710	32510	309650			4018240
2003 -04	589490	2429130	630670	13340	25570	355670			4043860
2004 -05	654190	3159900	838380	1250	24250	109380			4787340
2005 -06	700660	3120610	803170	2110	261 30	107040			4759720
2006 -07	725260	3196120	810020	2250	12150	137060			4882870
2007 -08	785680	3197180	903870	5210	19040	138800			5049780
2008 -09	790115	3245143	957035	15448	43965	75145			5126 851
2009 -10	773323	3336652	964902	17412	40186	85151			5217626
2010 -11	719206	3505287	1009981	6381	3814	19071			5263740
2011 -12	758963	3418147	1084594	11858	28326	20447			5322335
2012 -13	934342	3242440	1035736	34560	28320	97707			5373105
2013 -14	876803	3278838	1083535	33778	28318	101060			5402332
2014 -15	962039	3235184	1106705	27718	20232	96274			5448152
2015 -16	1194177	2954949	1164603	29718	18336	128564			5490347
2016 -17	1063486	3079001	1187823	27518	14553	154885			5527266
2017 -18	1072539	2981646	1220879	26856	12769	241925			5556614
2018 -19	1076141	2994466	1248616	8780	8065	238871	11960	583	5587482
2019 -20	1084245	3001120	1269661	7852	6825	242356	14524	1015	5627598
2020-21	1085431	3006076	1287013	6752	6124	245136	16524	1735	5654791

Note: Data from 1961-62 to 1981-82 Taken from Year wise Progress Report of BADC, data from 1982-83 to 1999-2000 taken from Census of Irrigation in Bangladesh by ATIA Project and data from 2000-01 to 2020-21 taken from Irrigation Equipment Survey Report of BADC.

B. Comparative Study of Area Coverage per Equipment (DTW, STW, LLP)

A. Comparative study of area coverage per equipment (DTW, STW & LLP) is given below in the Table-9.

Table-9: Comparative study of area coverage per equipment (DTW, STW & LLP)

Irrigation season	Irrigated Area ('000 ha)			Operational Equipment ('000 No.)			Area Coverage per Equipment		
	DTW	STW	LLP	DTW	STW	LLP	DTW	STW	LLP
1982-83	234	371	337	13.8	93.1	35.5	16.96	3.98	9.49
1983-84	263	480	342	15.5	120.3	36	16.97	3.99	9.50
1984-85	287	586	351	16.9	147	37	16.98	3.99	9.49
1985-86	304	586	356	17.9	146.9	37.5	16.98	3.99	9.49
1986-87	318	639	386	18.7	160.3	40.6	17.01	3.99	9.51
1987-88	345	753	402	20.3	188.7	42.3	17.00	3.99	9.50
1988-89	380	941	482	22.4	235.9	50.8	16.96	3.99	9.49
1989-90	384	1037	484	22.6	260	51	16.99	3.99	9.49
1990-91	365	1078	513	21.5	270.3	51.6	16.98	3.99	9.94
1991-92	434	1234	500	25.5	309.3	50.3	17.02	3.99	9.94
1992-93	437	1392	496	25.7	348.9	52.2	17.00	3.99	9.50
1994-95	502	1638	538	26.7	488.9	57.1	18.80	3.35	9.42
1995-96	540	2004	568	27.3	571.2	60.6	19.78	3.51	9.37
1996-97	475	2159	570	25.2	629.8	62.9	18.85	3.43	9.06
1997-98	465	2182	622	25.3	664.7	66.3	18.38	3.28	9.38
1998-99	507	2522	628	26.7	736.1	72.9	18.99	3.43	8.61
1999-00	529.64	2122.51	581.80	23.53	707.57	58.05	22.51	3.00	10.02
2000-01	538.26	2295.66	603.28	23.18	865.21	71.31	23.22	2.65	8.46
2001-02	530.29	2355.03	628.75	23.00	893.36	77.00	23.06	2.64	8.17
2002-03	587.93	2409.41	664.02	23.43	924.02	79.87	25.09	2.61	8.31
2003-04	589.49	2429.13	630.67	24.72	925.15	77.79	23.85	2.63	8.11
2004-05	654.19	3159.90	838.38	27.18	1128.99	99.25	24.07	2.80	8.45
2005-06	700.66	3120.61	803.17	28.28	1182.52	119.13	24.78	2.64	6.74
2006-07	725.26	3196.12	810.02	29.17	1202.72	107.29	24.86	2.66	7.55
2007-08	785.68	3197.18	903.87	31.30	1304.97	138.63	25.10	2.45	6.52
2008-09	790.12	3245.14	957.04	32.17	1374.55	146.79	24.56	2.36	6.52
2009-10	773.323	3336.65	964.90	32.91	1425.14	150.61	23.5	2.34	6.41
2010-11	719.206	3505.287	1009.981	336.70	15491.49	1736.69	21.36	2.26	5.82
2011-12	758.963	3418.147	1084.594	340.45	14983.86	1772.16	22.23	2.28	6.12
2012-13	934.342	3242.440	1035.736	353.22	15236.09	1705.69	26.45	2.13	6.07
2013-14	876.803	3278.838	1083.535	360.34	15367.91	1710.41	24.33	2.10	6.33
2014-15	962.039	3235.184	1106.705	365.66	15497.11	1671.75	26.30	2.08	6.62
2015-16	1194.177	2954.949	1164.603	369.79	14170.08	173179	32.29	2.08	6.72
2016-17	1063.486	3079.001	1187.823	371.75	13989.60	1764.78	28.60	2.20	6.73
2017-18	1072.539	2981.646	1220.879	375.38	13558.52	1814.69	28.57	2.19	6.72
2018-19	1076.141	2994.466	1248.616	376.34	13575.32	1871.88	28.59	2.21	6.67
2019-20	1084.245	3001.120	1269.661	370.07	13987.06	1999.14	29.30	2.15	6.35
2020-21	1085.431	3006.076	1287.013	369.55	14096.49	2043.91	29.37	2.13	6.29

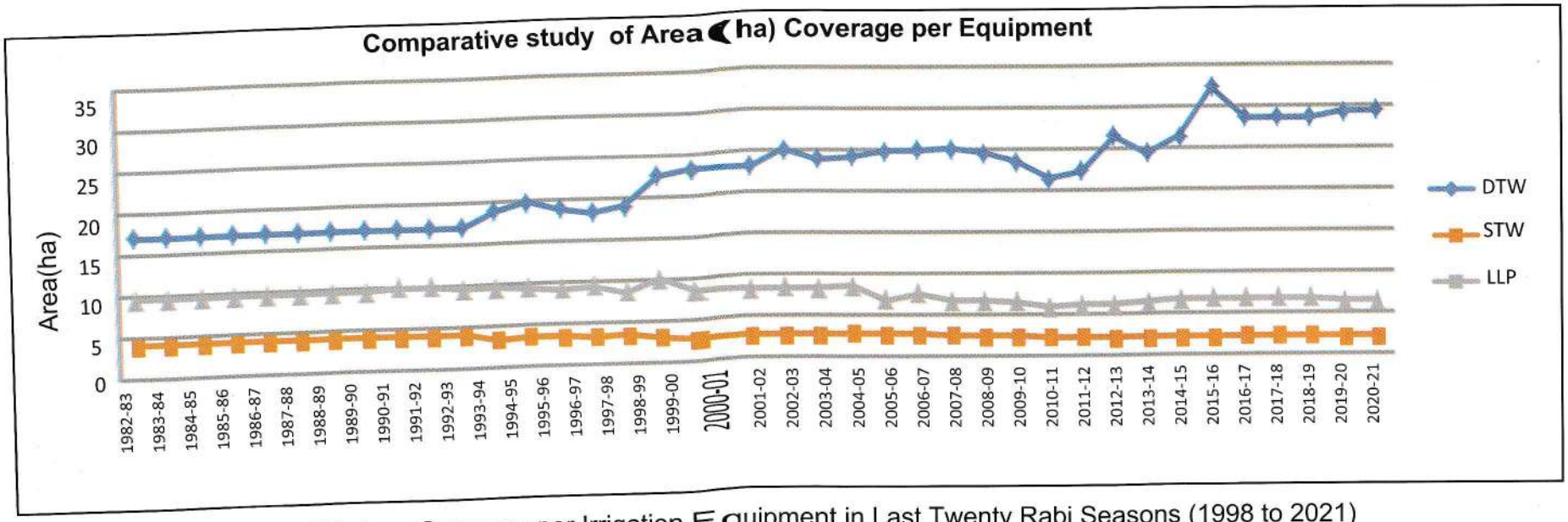


Figure 36: Area Coverage per Irrigation Equipment in Last Twenty Rabi Seasons (1998 to 2021)

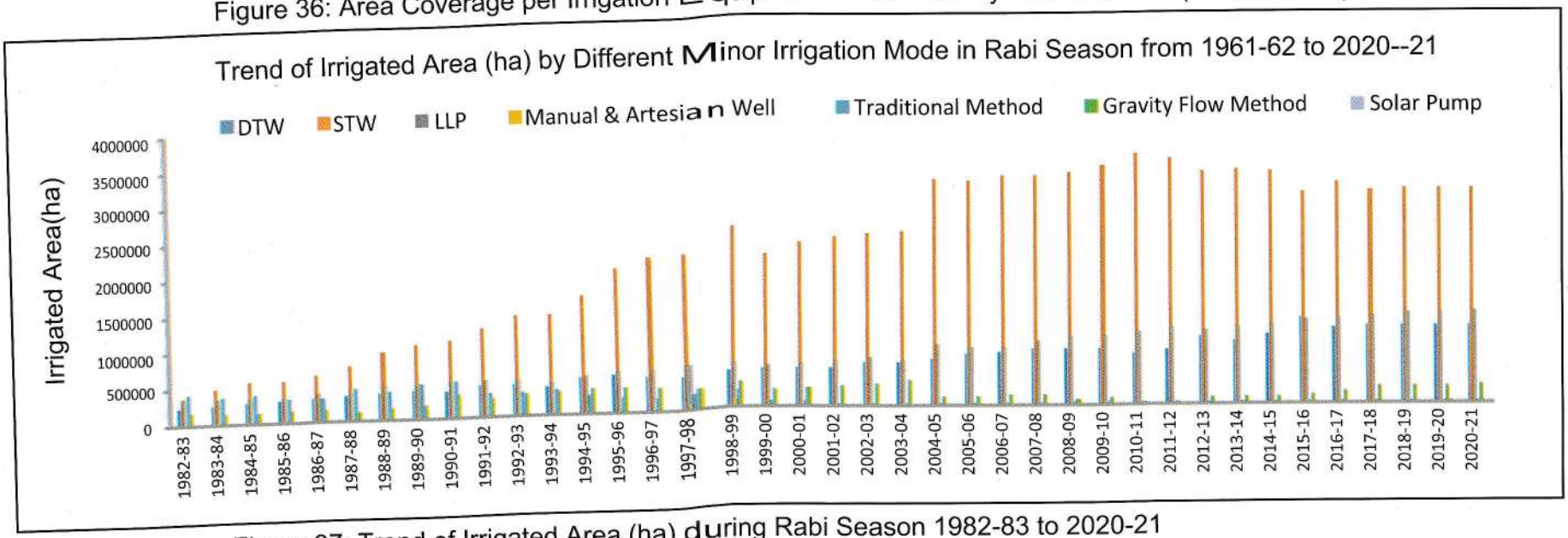


Figure 37: Trend of Irrigated Area (ha) during Rabi Season 1982-83 to 2020-21

POWER SOURCE IN IRRIGATION EQUIPMENT

During 2020-21 Rabi season huge number of power operated irrigation equipment are used all over the country. Power operated equipment's are operated either by diesel or electricity. Recently solar energy is used for generating electricity to operate the small capacity irrigation pumps. Survey has been made to determine number of diesel or electricity operated various types of equipment's used all over the country. Different modes of irrigation equipment on the basis of Power Source are shown in the Table-10 and graphical presentation in Figure-29.

Table-10: Division Wise Distribution of Irrigation Equipment on the basis of Power Source

Division	Electric		Diesel		Total	
	Number	Area (ha)	Number	Area (ha)	Number	Area (ha)
Dhaka	72486	306604	128589	369937	201075	676541
Mymensingh	58507	311835	112617	276488	171124	588321
Rajshahi	100842	754117	230528	475302	331370	1229419
Rangpur	106668	463183	296944	586148	403612	1049331
Chittagong	40977	256244	83148	317879	124125	574123
Khulna	41511	187960	279904	549566	321415	737526
Sylhet	10865	60275	61033	287374	71898	347649
Barisal	1390	18752	25026	156856	26416	175608
Total	433246	2358970	1217789	3019550	1651035	5378520

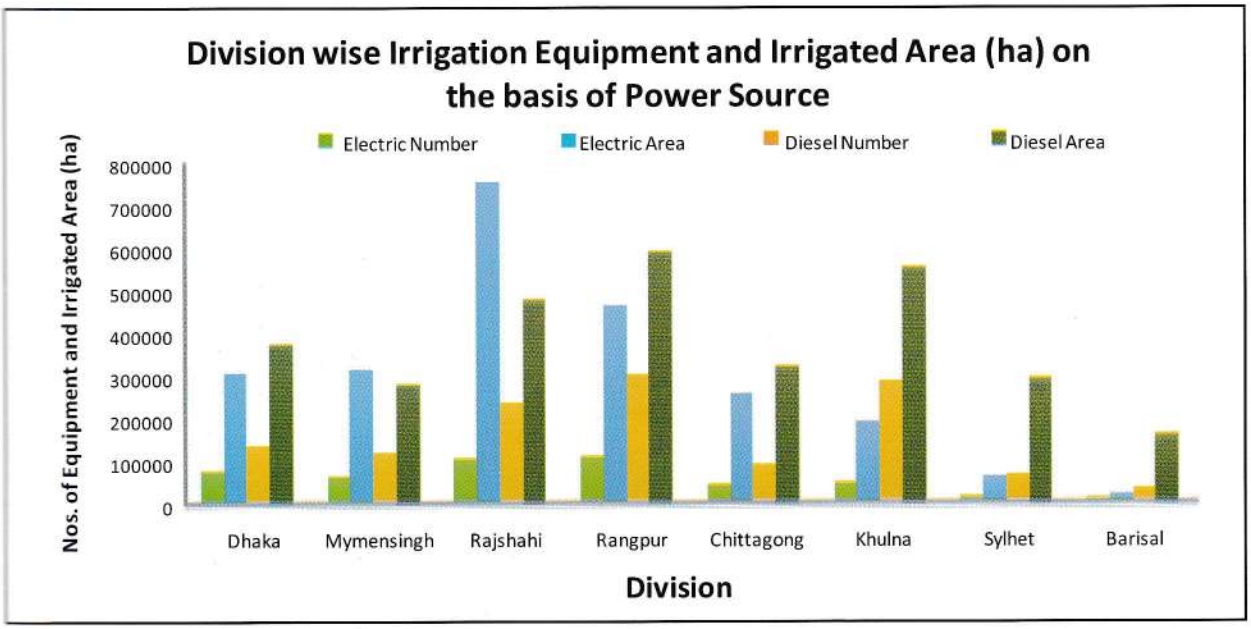


Figure 38: Bar Diagram showing Number of Electrically and Diesel Operated Different types of Equipment's and Irrigated Area (ha) during Rabi Season 2020-21

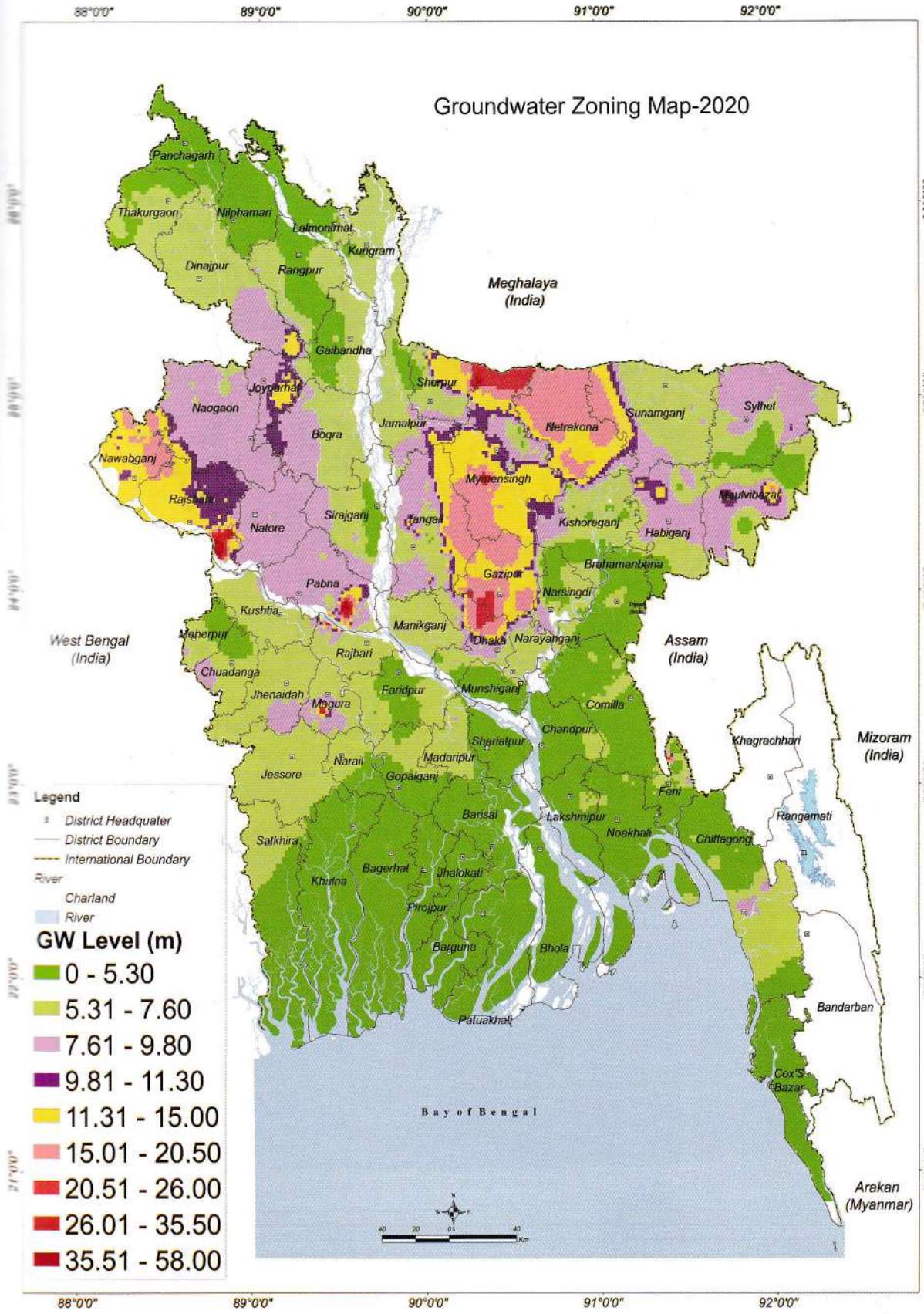


Figure 39: Groundwater Zoning Map - 2020

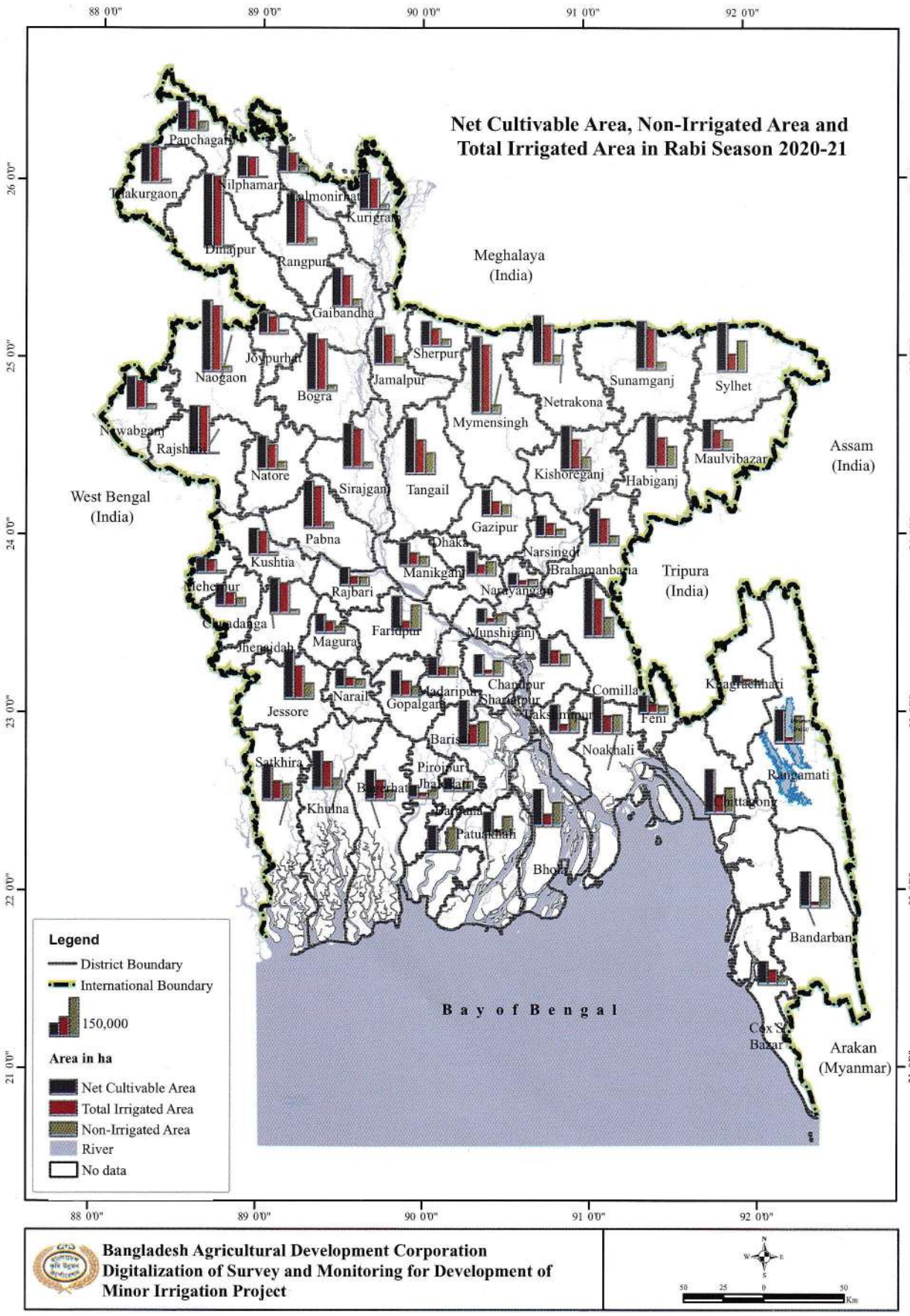


Figure 40: Net Cultivable Area

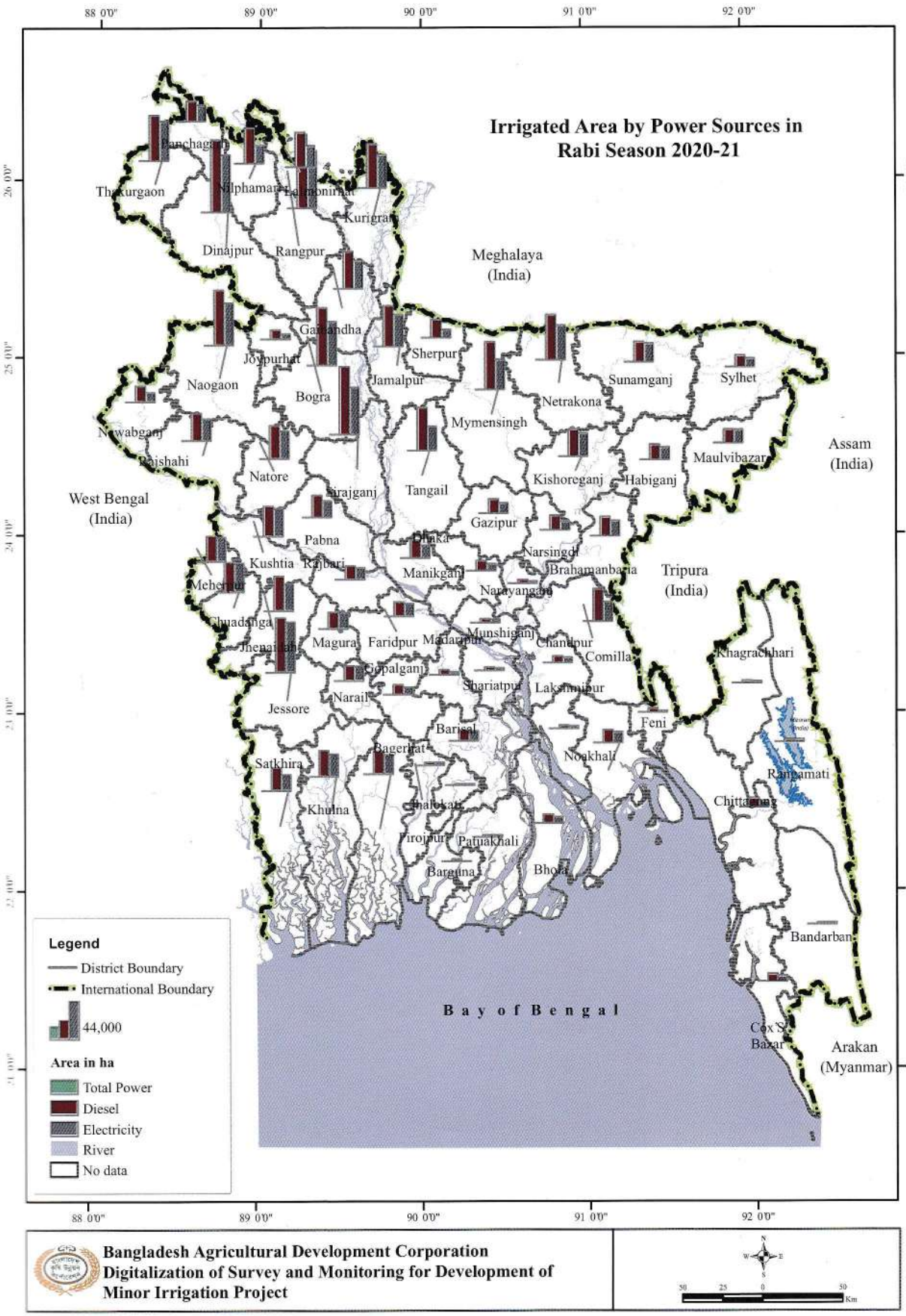


Figure 41: Irrigated Area By Power Source.

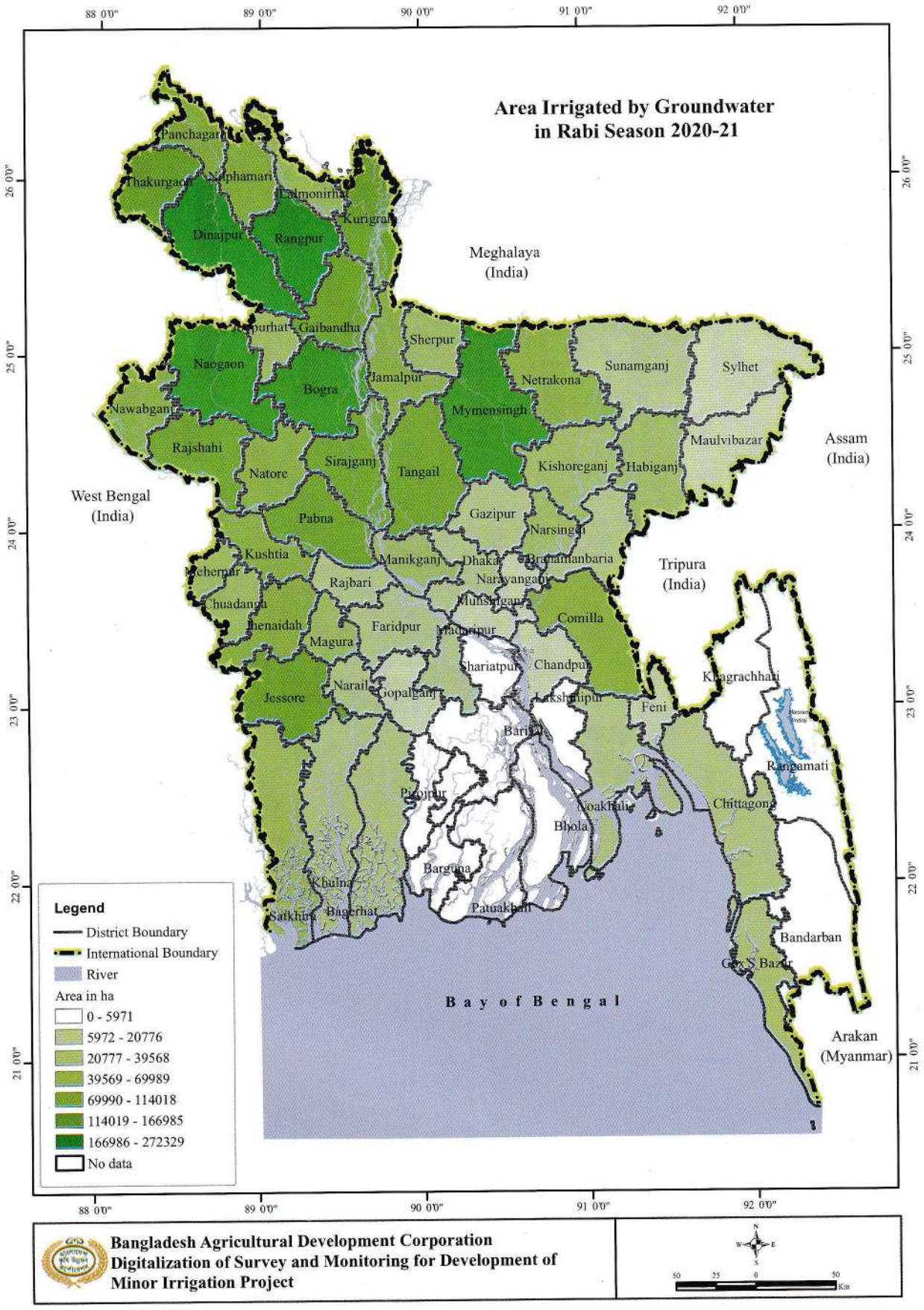


Figure 42: Area Irrigated By Groundwater.

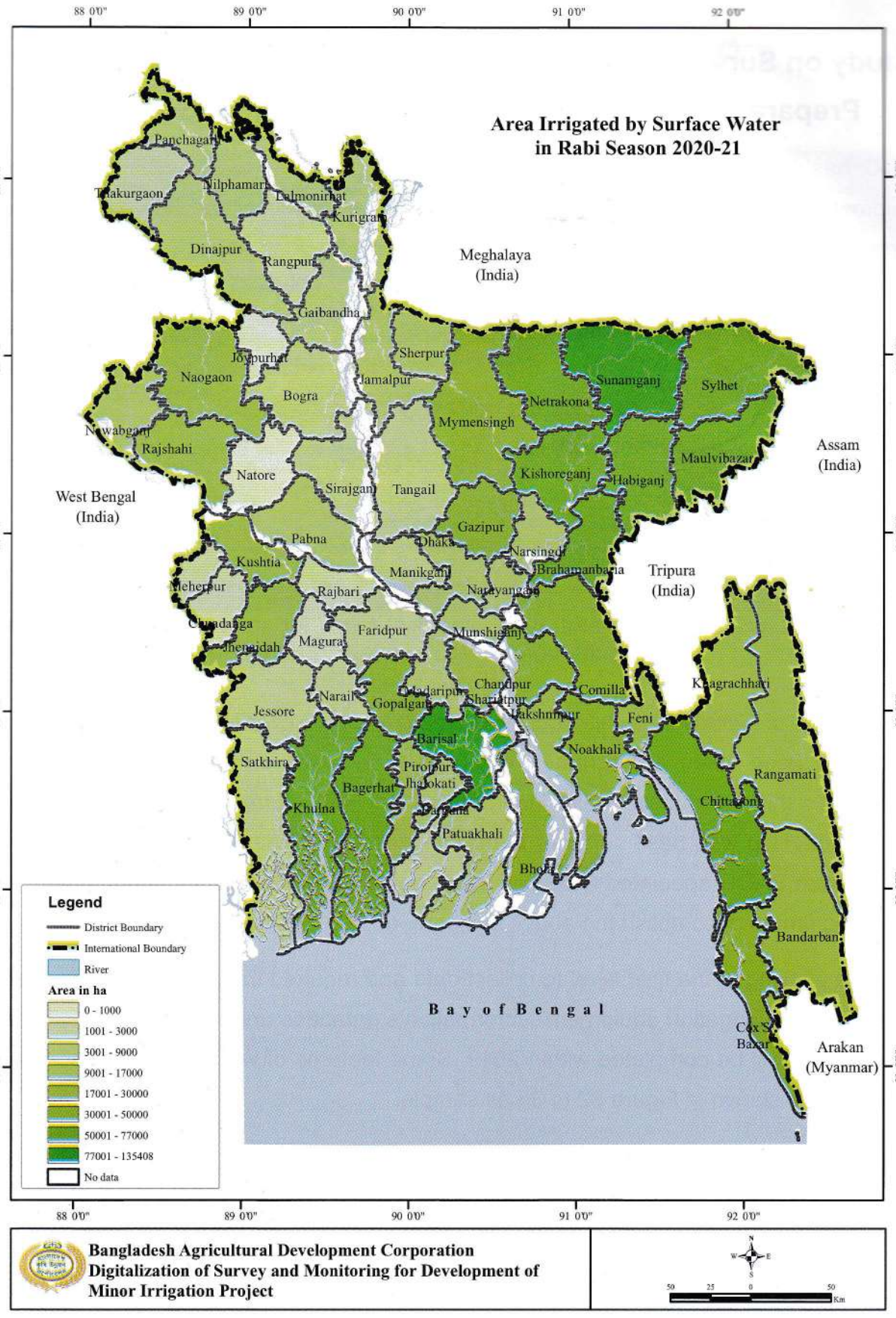


Figure 43: Area Irrigated By Surface water.

Study on Survey of Minor Irrigation Equipment, Area, Costing, Preparation of Data Base and Development of Software

BADC has been implementing survey and monitoring activities such as irrigation equipment, irrigated area, irrigation cost and crop production cost, source of power, pump capacity, benefitted farmers etc. in all over the country since 1999. The Survey was conducted through appointing enumerator and field employees of BADC, BMDA and DAE. On the basis of these collected data Annual Survey Report has been published during last two decades to provide technical assistance and suggestions to the government and policy makers for formulation of Minor Irrigation Policy.

At the era of Digitalization in processing and preserving or storing the above collected information's/data, it is essential to create a database and to develop a web base software for survey and monitoring of Minor Irrigation activities, cardinal information's are needed like Table, Graphs, Maps, GIS database etc. so it is important to prepare GIS database including Maps and 3D geometrical Maps for surface water and ground water too.

Digitalization of Survey & Monitoring for Development of Minor Irrigation Project under BADC has been taken a program to establish a database on about 16 lac irrigation equipment's through questionnaire incorporated with 49 columns needful information's and also develop web base software to meet necessary queries about irrigation. Under this program BADC appointed CEGIS a trusty board of Water Resources Ministry as a consulting firm to accomplish the above assignment.

They are working in the field level to collect data and required information's about minor irrigation. Hope irrigation equipment's information's database and its web base software development will be completed within 2019. Some features of web base applications of the Study are shown in Figure 32 to 35 as sample.

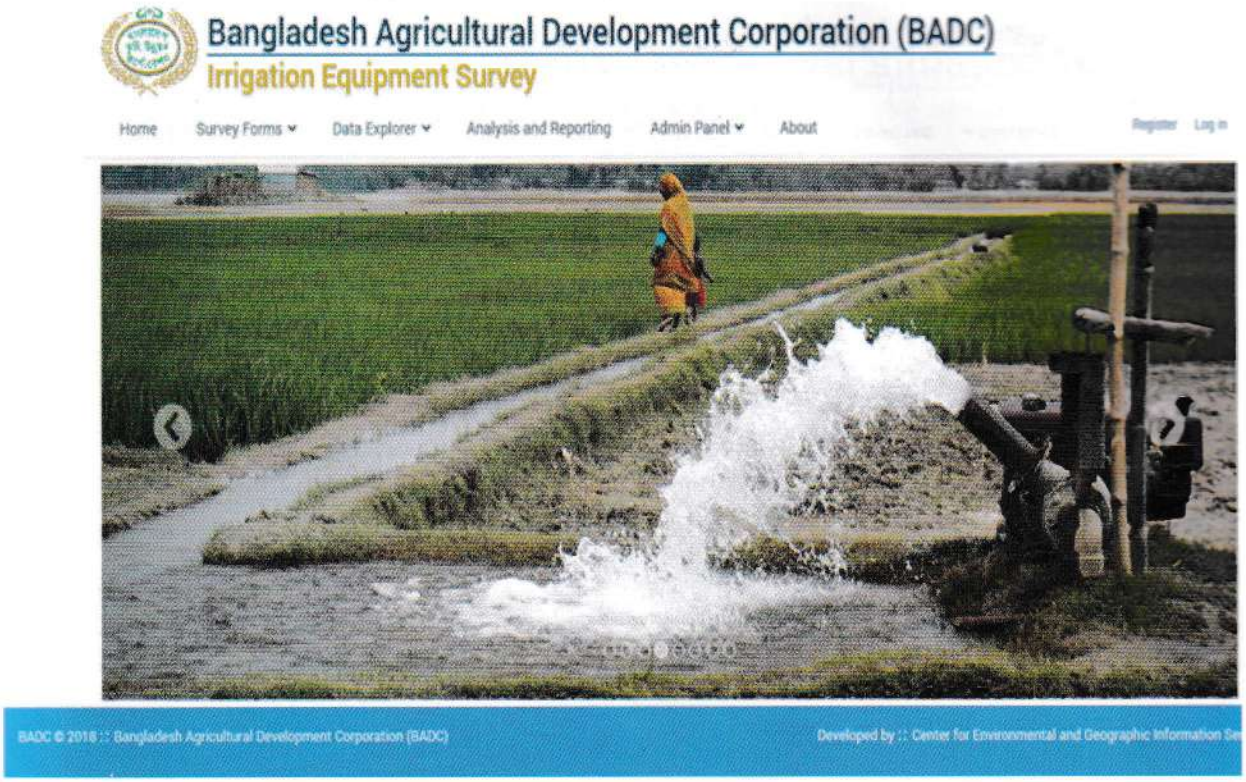
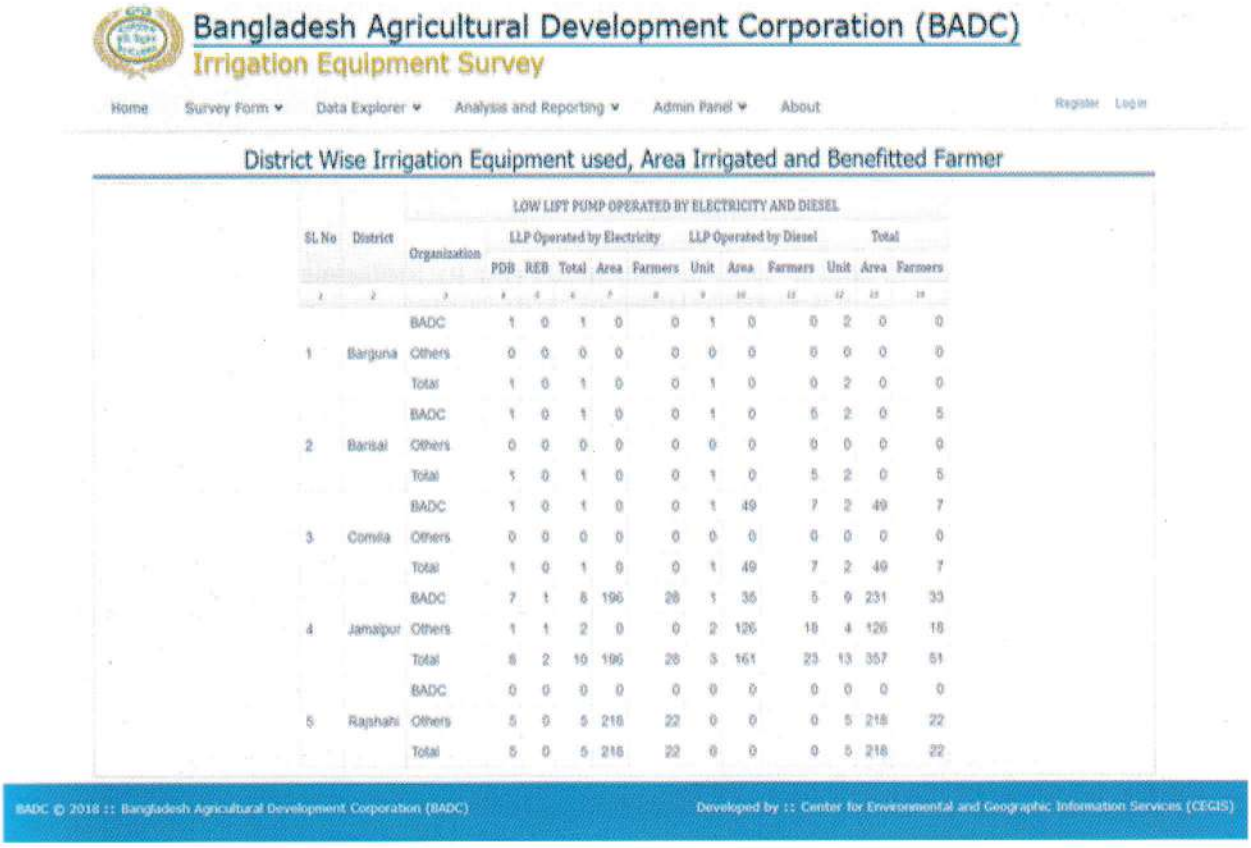


Figure 44: Features of Web Applications



LOW LIFT PUMP OPERATED BY ELECTRICITY AND DIESEL

SL No	District	Organization	LLP Operated by Electricity					LLP Operated by Diesel			Total		
			PDB	REB	Total	Area	Farmers	Unit	Area	Farmers	Unit	Area	Farmers
		BADC	1	0	1	0	0	1	0	0	2	0	0
1	Barguna	Others	0	0	0	0	0	0	0	0	0	0	0
		Total	1	0	1	0	0	1	0	0	2	0	0
		BADC	1	0	1	0	0	1	0	5	2	0	5
2	Barisal	Others	0	0	0	0	0	0	0	0	0	0	0
		Total	1	0	1	0	0	1	0	5	2	0	5
		BADC	1	0	1	0	0	1	49	7	2	49	7
3	Comilla	Others	0	0	0	0	0	0	0	0	0	0	0
		Total	1	0	1	0	0	1	49	7	2	49	7
		BADC	7	1	8	196	28	1	35	5	9	231	33
4	Jamalpur	Others	1	1	2	0	0	2	126	18	4	126	18
		Total	8	2	10	196	28	3	161	23	13	357	51
		BADC	0	0	0	0	0	0	0	0	0	0	0
5	Rajshahi	Others	5	0	5	216	22	0	0	0	5	216	22
		Total	5	0	5	216	22	0	0	0	5	216	22

Figure 45: Features of Web Applications

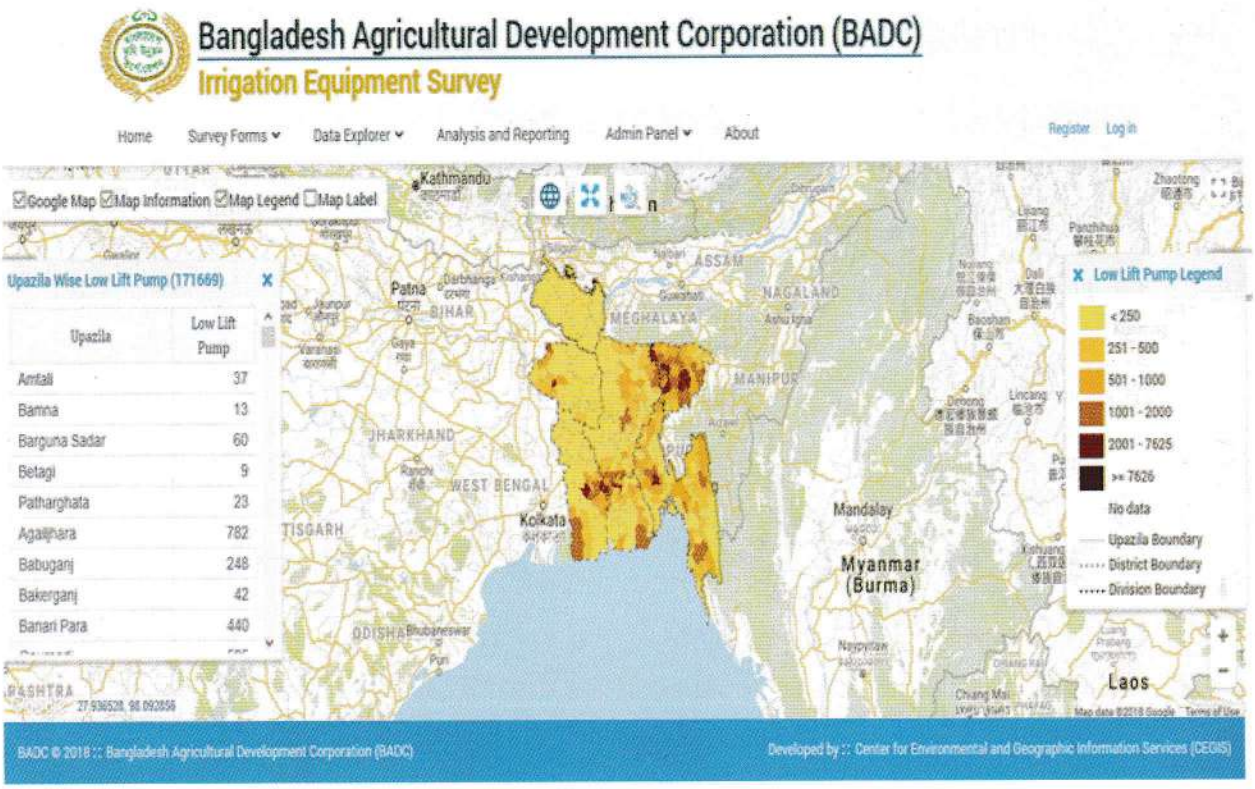


Figure 46: Features of Web Application

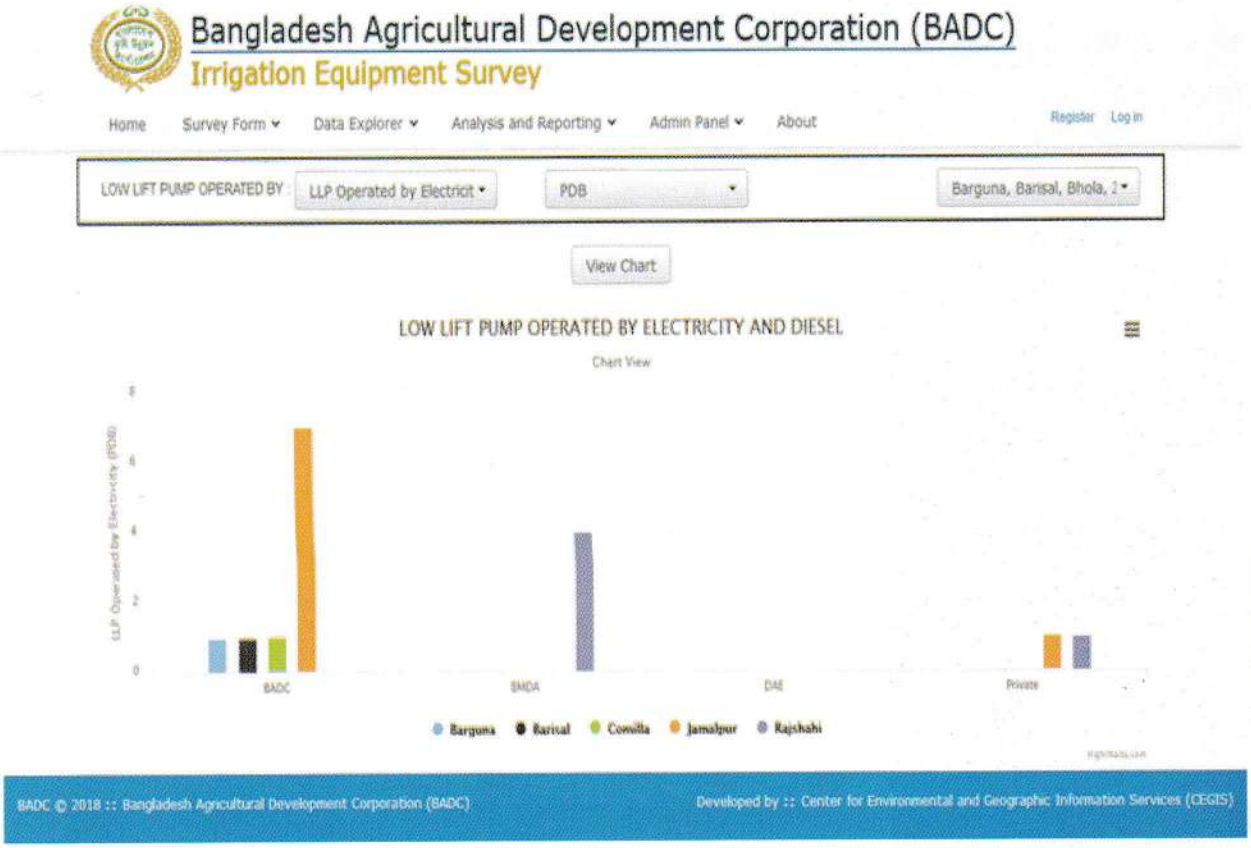


Figure 47: Features of Web Applications

Groundwater recharge and withdrawal situation for irrigation purpose

Bangladesh is a deltaic country located within the flood plains of the three great rivers, the Brahmaputra, Ganges, and Meghna and their tributaries. The three major river networks often called the GBM river system drain to the Bay of Bengal through Bangladesh. The country is under tropical climate with heavy monsoon rain between the months of May- September. About 80% of the total annual rainfall occurs in between July- September. The average rainfall is 200 cm. The temperature rises from the month of February to the month of May and varies 50C - 420C. The overall climate is suitable for production of crops including high yielding variety round the year.

Groundwater is the water beneath surface of the earth which fills the pore spaces of the alluvium, soil or rock formation with water and flowing by gravity below the ground surface. Aquifer is a saturated permeable geologic formation which can yield significant quantities of water to wells and springs. Groundwater reservoir is other terms often used in place of the word aquifer. Sands constitute an aquifer which contains fresh water. Groundwater is the most vital natural resources of Bangladesh which contributes to about 73.09% of the total irrigated area. The top of the water level in these reservoir is water table which liable to variations throughout the year. The static water level is the level to which water rises and water stands at rest in a well, when the well is not being pumped. When the well is pumped, the removal of water from the well (discharge) causes a drop in head (drawdown) in the well and water flows from the aquifer to the well and cone of depression expands until the amount of water removed from the well is balanced by the amount of water draining from the aquifer.

The recharge is the resultant of the balances of flow in the unsaturated zone for wet periods i.e. any addition to the groundwater reservoir by percolation through the land surface. Groundwater recharging in Bangladesh is occurred by the monsoon rainfall, flow from the rivers & canals, lateral groundwater movement and irrigation return. Groundwater level rises during wet periods by recharging and reached at minimum depth below the ground surface. With the cessation of recharge, the groundwater depletion begins by rapid drainage of surface water, response of evapotranspiration and withdrawal of groundwater for irrigation in dry season. The level reached at maximum depth (drawdown) in the dry season by the groundwater losses.

The project has been monitoring the groundwater level round the year from 201 nos. of Automatic Water Level Recorders (AWLR) and 10 nos. of selected tube wells in each upazila all over the country. So, a unique network of water level recording system has been established throughout the country.

Hydrograph refers to a graph showing the groundwater levels over time in a particular year. The data recorded in AWLR's from 2006-2018 are used for preparing the hydrographs. In this report, representative **4 nos. hydrographs of 17 upazilas for 14 years** are incorporated. The hydrographs have reflected the recharging of groundwater level and declining level (losses of groundwater) i.e. drawdown due to withdrawal groundwater in the dry seasons for irrigation for the years 2006-2018. It is observed that the maximum drawdown occurred at Gazipur Sadar of Gazipur district. The maximum depletion of groundwater levels in the dry season was 37.38 m in March/2018

From the hydrographs it is depicted that the Gazipur Upazila is more critical for utilization of groundwater both for irrigation, industrial and domestic purposes. Others Upazilas are quite feasible for withdrawal of groundwater for irrigation.

Groundwater Table Hydrographs

Year	Upazila/District	No. of DTW	No. of STW	Irrigated Area (ha) for Rabi crop	Maximum Depletion Groundwater Level (m) (Jan-March)
2005-06	Fulbaria Mymensingh	579	1773	14874	13.29
2006-07		587	1300	14730	13.14
2007-08		632	1844	21213	11.48
2008-09		279	2336	11196	14.26
2009-10		666	13973	47611	14.07
2010-11		609	2280	18640	12.41
2011-12		641	2386	21466	10.06
2012-13		625	2408	20151	12.58
2013-14		589	1798	20033	14.21
2014-15		641	2447	26304	14.39
2015-16		626	2447	26397	14.82
2016-17		625	2452	26345	15.04
2017-18		628	2542	24067	15.71
2018-19		595	2694	34467	12.25
2005-06	Modhupur Tangail	66	8234	27233	7.97
2006-07		50	4060	14015	8.92
2007-08		54	4128	11577	5.56
2008-09		93	4535	11042	6.19
2009-10		52	4982	10820	5.87
2010-11		87	6203	14596	5.98
2011-12		57	6297	14381	5.85
2012-13		57	6297	12070	5.51
2013-14	Modhupur Tangail	51	4853	13955	5.97
2014-15		57	5657	14110	5.87
2015-16		68	5680	12190	6.18
2016-17		68	5680	9117	5.86
2017-18		78	5641	9788	6.95
2018-19		82	5197	9416	6.52
2019-20		83	5220	9530	5.47
2020-21		83	5520	9530	5.65
2005-06	Sadar Gazipur	181	745	5837	18.36
2006-07		162	638	5056	19.93
2007-08		143	654	4732	20.57
2008-09		192	866	8407	23.17

Year	Upazila/District	No. of DTW	No. of STW	Irrigated Area (ha) for Rabi crop	Maximum Depletion Groundwater Level (m) (Jan-March)
2005-06	Sadar Gazipur	181	745	5837	18.36
2006-07		162	638	5056	19.93
2007-08		143	654	4732	20.57
2008-09		192	866	8407	23.17
2009-10		123	897	5217	24.1
2010-11		147	1028	5911	24.93
2011-12		130	1074	3659	29.75
2012-13		98	1181	3816	30
2013-14		76	1080	3198	31.78
2014-15		76	647	2060	32.02
2015-16		60	489	2594	33.72
2016-17		60	1017	4271	37.38
2017-18		61	994	3299	32.22
2018-19		62	1033	3303	28.42
2019-20		63	1333	3410	27.43
2020-21		63	2940	2912	52.27
2005-06	Saturia Manikganj	43	3658	6782	6.05
2006-07		45	2762	6212	6.33
2007-08		44	3578	6466	6.12
2008-09		45	4216	9803	5.97
2009-10		47	4378	7554	6.69
2010-11		44	5047	11509	5.77
2011-12		44	4980	11524	6.23
2012-13		41	4477	5975	5.73
2013-14		38	3160	7272	5.77
2014-15		43	4253	5416	5.67
2015-16	Saturia Manikganj	43	4253	5416	5.62
2016-17		40	3459	5231	5.56
2017-18		40	3294	6242	5.54
2018-19		40	3316	6505	6.18
2019-20		42	2390	6520	5.62
2020-21		42	2432	6575	5.03
2005-06	Savar Dhaka	145	542	6389	10
2006-07		133	475	6225	9.92
2007-08		146	495	4578	8.83
2008-09		92	453	2919	10.14
2009-10		128	490	6362	10.21
2010-11		125	555	4304	10.52
2011-12		112	485	7536	11.64
2012-13		105	436	4664	11.72
2013-14		98	425	3608	12.7
2014-15		99	361	5312	12.88
2015-16		99	361	6412	13.14
2016-17		91	462	5595	13.02
2017-18		77	651	5493	12.1
2018-19		61	661	4286	14.23
2019-20		62	1161	4590	14.85
2020-21		62	961	4390	

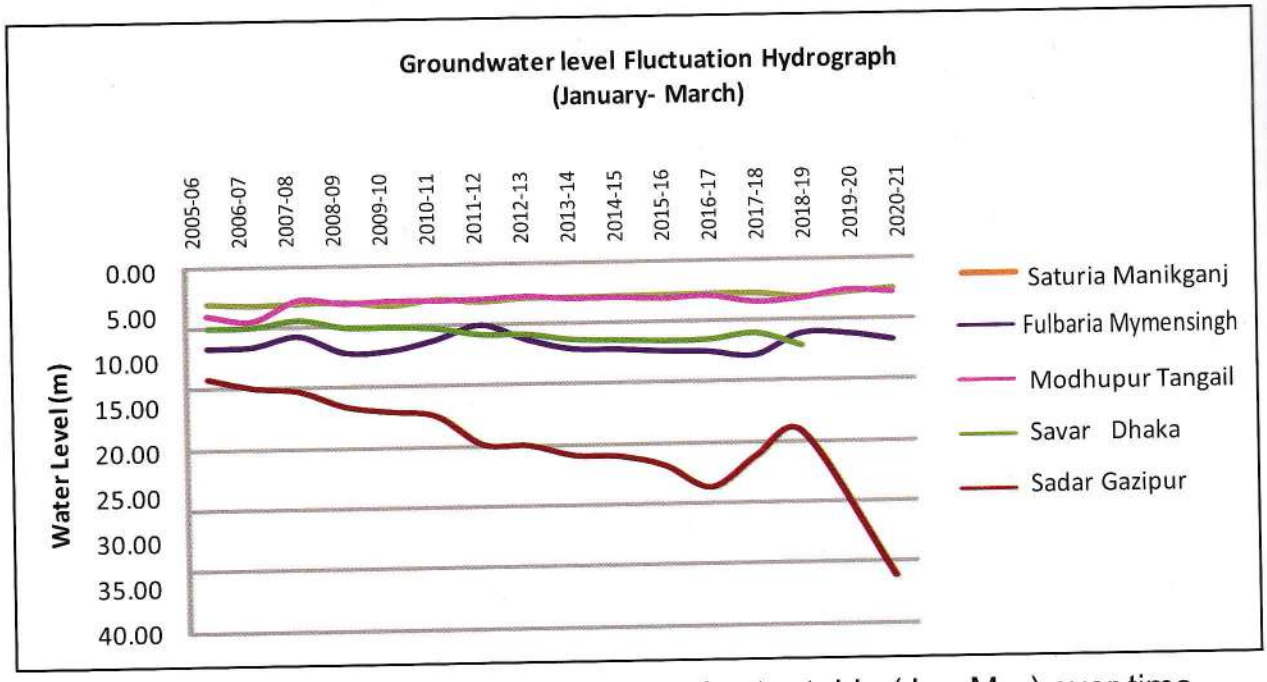


Figure 48:Changes in the depth of groundwater table (Jan-Mar) over time

The above figure 48 prepared by the maximum depth of groundwater level over the last 13 years (2006-2018) and it is indicating the fluctuation of groundwater level in the north central region of Bangladesh. The hydrograph implies that in the dry period (January-March), Gazipur sadar groundwater level found 32.22m in 2018 which is 5.16m raises than previous year (37.38 m) and in Fulbaria of Mymensingh maximum depth is 15.71 m and in Savar of Dhaka groundwater level found 12.10m in 2018 which is 0.92m raises than previous year (13.02 m).

Groundwater Table Hydrographs

Year	Upazila/District	No. of DTW	No. of STW	Irrigated Area (ha) for Rabi crop	Maximum Depletion Groundwater Level (m) (Jan-March)
2005-06	Bagmara Rajshahi	444	4807	33452	8.95
2006-07		527	4593	36885	10.31
2007-08		643	5282	28607	9.89
2008-09		806	3829	36512	10.98
2009-10		673	3619	18489	9.85
2010-11		794	2572	18736	11.35
2011-12		602	3222	19419	11.2
2012-13		890	2052	48321	10.66
2013-14		904	596	26586	11.01
2014-15		869	3345	37313	11.13
2015-16		746	3345	46183	12.25
2016-17		854	1350	21285	13.45
2017-18		859	1355	24085	11.83
2018-19		860	3190	24230	11.93
2019-20		785	2550	22540	11.11
2020-21		785	2290	24304	12.17

Year	Upazila/District	No. of DTW	No. of STW	Irrigated Area (ha) for Rabi crop	Maximum Depletion Groundwater Level (m) (Jan-March)
2005-06	Fulbari Dinajpur	128	5852	19012	6.19
2006-07		176	5678	17455	7.14
2007-08		214	5674	19361	6.63
2008-09		215	5408	11151	7.17
2009-10		216	5503	14227	6.79
2010-11		213	5515	19273	6.55
2011-12		211	1600	10028	5.97
2012-13		222	5542	17859	7.06
2013-14		226	5015	14922	6.84
2014-15		229	5052	16229	6.98
2015-16		229	5052	14712	6.92
2016-17		232	5599	13955	6.23
2017-18	Fulbari Dinajpur	237	5604	18888	6.89
2018-19		234	6950	23579	6.59
2019-20		240	7550	23989	7.87
2020-21		238	8250	24007	7.28
2005-06	Kahaloo Bogra	594	20775	29461	6.86
2006-07		561	632	26832	7.32
2007-08		214	615	7287	7.23
2008-09		574	5408	29822	7.6
2009-10		535	687	26836	7.81
2010-11		563	735	14376	8.01
2011-12		556	699	13692	7.99
2012-13		567	680	18110	8.14
2013-14		581	8628	40769	8.5
2014-15		585	570	20703	8.63
2015-16		617	570	24744	8.57
2016-17		572	670	25323	9.12
2017-18		574	675	23553	9.15
2018-19		632	575	25219	8.85
2019-20		614	635	25590	8.29
2020-21		614	1635	22592	8.27
2005-06	Mithapukur Rangpur	168	8200	24360	3.37
2006-07		134	10456	25850	3.3
2007-08		148	10836	34603	3.82
2008-09		149	11720	28803	3.91
2009-10		140	12800	30925	3.29
2010-11		120	18014	45043	3.13
2011-12		224	24271	45113	3.67
2012-13		209	19041	36842	3.84
2013-14		235	7398	20255	3.95
2014-15		256	15859	41846	4.01
2015-16		267	14690	44287	4.25
2016-17		263	14316	30849	3.5
2017-18	Mithapukur Rangpur	268	14320	34218	4.1
2018-19		318	29146	44202	4.44
2019-20		333	25255	45550	4.14
2020-21		333	25255	45570	3.17
2005-06	Mohadevpur Naogoan	512	10713	25595	6.85
2006-07		510	10971	26080	7.01
2007-08		525	11554	33736	7.17
2008-09		549	11275	30750	7.45
2009-10		568	11542	32561	7.45
2010-11		570	14603	47398	6.84
2011-12		571	13540	47754	7.2
2012-13		572	15578	33635	6.6
2013-14		571	5580	26066	7.15
2014-15		571	15578	27610	7.38
2015-16		571	15578	29467	7.45
2016-17		571	3378	29090	8.45
2017-18		575	3385	29872	7.5
2018-19		571	6760	25735	7.4
2019-20		580	6810	25990	7.55
2020-21		571	6810	26090	8.06

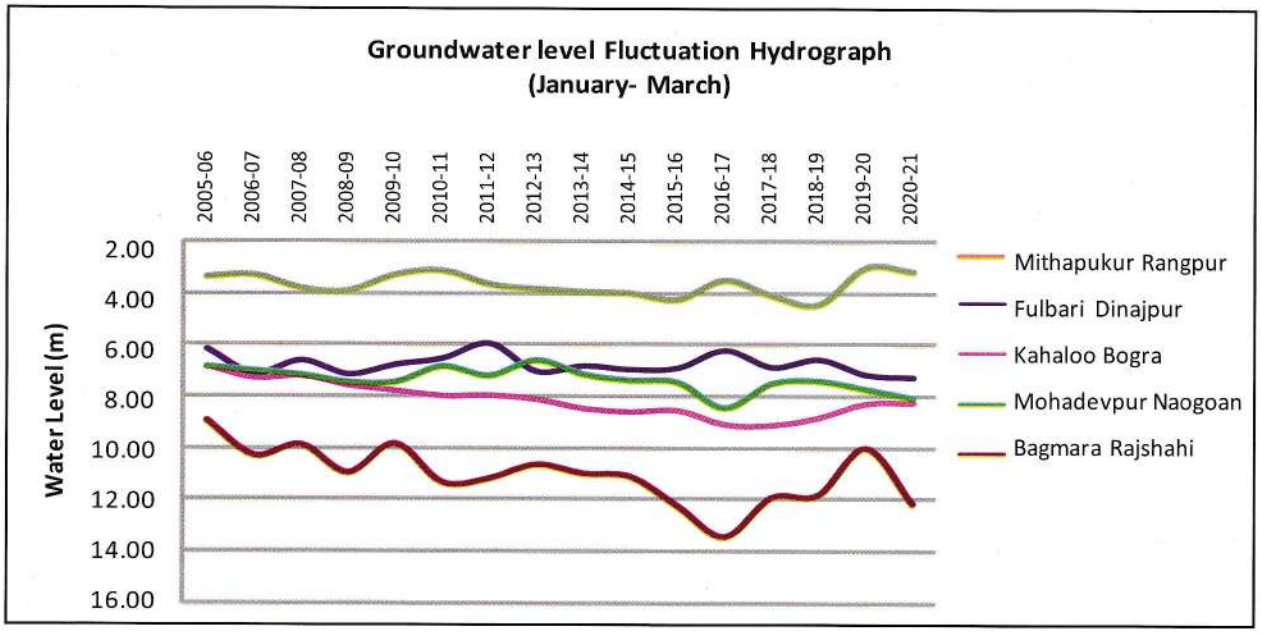


Figure 49:Changes in the depth of groundwater table (Jan-Mar) over time

The above figure-49 prepared by the maximum depth of groundwater table over the last 15 years (2006-2021) is indicating the fluctuation of groundwater table in the north western region of Bangladesh. The hydrograph implies that in the dry period (January-March), Bagmara Rajshahi groundwater table declined and it was about 11.83m in 2018 which is 1.62m raises than inMarch/2017 (13.45m). The other Upazila's was within the capacity of the suction mode pump.

Groundwater Table Hydrographs

Year	Upazila/District	No. of STW	Irrigated Area (ha) for Rabi crop	Maximum Depletion Groundwater Level (m) (Jan-March)
2005-06	Jhikorgacha Jessore	7025	22409	7.13
2006-07		8205	18680	6.26
2007-08		7932	24064	5.5
2008-09		7863	21282	5.44
2009-10		8501	19513	5.35
2010-11		9407	28164	5.76
2011-12		8298	22282	5.74
2012-13		4932	15845	6.52
2013-14	Jhikorgacha Jessore	9217	23134	5.37
2014-15		7967	16665	5.79
2015-16		8578	18251	5.85
2016-17		8226	19073	6.2
2017-18		8230	23426	6.66
2018-19		8240	24251	6.56
2019-20		8261	25520	6.14
2020-21		8261	22920	5.22

Year	Upazila/District	No. of STW	Irrigated Area (ha) for Rabi crop	Maximum Depletion Groundwater Level (m) (Jan-March)
2005-06	Kalaroa Sathkhira	2950	10925	6.52
2006-07		2526	11432	7.32
2007-08		3674	14255	7.23
2008-09		2650	17313	5.89
2009-10		2659	14001	5.32
2010-11		4208	19172	5.94
2011-12		4050	18241	5.09
2012-13		4048	16156	4.92
2013-14		4116	13967	5.22
2014-15		4116	13967	5.29
2015-16		1056	14699	5.14
2016-17		2057	17907	5.12
2017-18		2392	18383	5.22
2018-19		3392	19770	5.25
2019-20		3590	20110	6.75
2020-21		3590	19969	5.01
2005-06	Sadar Chuadanga	6603	12019	6.1
2006-07		6903	13503	6.09
2007-08		6683	13743	5.16
2008-09		6106	15720	5.9
2009-10		6575	16470	5.6
2010-11		7120	17596	6.32
2011-12		9638	21298	5.46
2012-13		8270	12564	6.21
2013-14		11475	13733	5.71
2014-15		6510	8488	6.02
2015-16	Sadar Chuadanga	7030	13738	6.12
2016-17		11558	23633	6.22
2017-18		11573	25431	5.4
2018-19		13573	25731	5.35
2019-20		13825	26250	6.13
2020-21		13825	25250	5.05
2005-06	Sadar Jhenaidah	11500	24073	5.89
2006-07		11902	23515	5.93
2007-08		13182	29038	4.56
2008-09		12645	24760	5.12
2009-10		12876	25460	5.27
2010-11		13342	39525	5.67
2011-12		10809	26128	5
2012-13		10034	17751	4.58
2013-14		18239	24614	4.9
2014-15		11368	19170	5.02
2015-16		6752	19545	4.98
2016-17		7990	21210	5.03
2017-18		8005	21533	5.04
2018-19		7400	21910	5.78
2019-20		9340	22855	5.85
2020-21		9320	23755	5.33

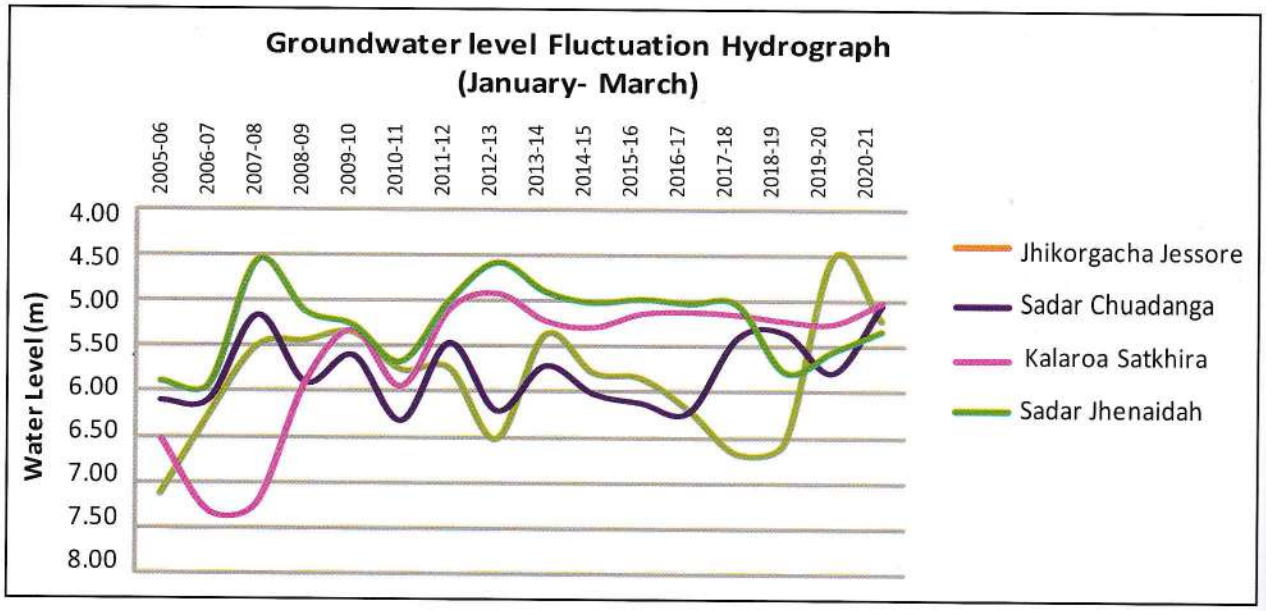


Figure 50:Changes in the depth of groundwater table (Jan-Mar) over time

The above figure-50 prepared by the average depth of groundwater table over the last 15 years (2006-2021) is indicating the fluctuation of groundwater table in the South-Western region of Bangladesh. The hydrograph implies that in the dry period (January-March), all the upazila's water level was within the range of the suction lift pump.

Groundwater Table Hydrographs

Year	Upazila/District	No. of DTW	No. of STW	Irrigated Area (ha) for boro crop	Maximum Depletion Groundwater Level (m) (Jan-March)
2005-06	Chowdagram Comilla	217	1162	10990	5.67
2006-07		214	1161	11110	5.85
2007-08		225	1147	11344	5.07
2008-09		226	1467	11645	5.63
2009-10		217	1357	10454	4.83
2010-11		213	1551	6276	4.88
2011-12		219	1634	8525	5.05
2012-13		176	1438	9185	5.13
2013-14		221	1395	8935	5.23
2014-15		221	1666	8410	5.12
2015-16		222	1600	13133	5.45
2016-17		220	1530	9225	6.03
2017-18		230	1535	13616	4.4
2018-19		158	1535	11616	3.85
2019-20		138	1345	10620	4.38
2020-21		138	1345	9620	
2005-06	Kachua Chandpur	144	891	8310	4.56
2006-07		146	934	9544	4.02
2007-08		146	1104	8519	4.08
2008-09		146	1163	7904	3.04
2009-10		141	1252	9925	3.36
2010-11		140	1454	6005	3.09
2011-12		128	1525	7820	3.52

Year	Upazila/District	No. of DTW	No. of STW	Irrigated Area (ha) for boro crop	[illegible]
2011-12		128	1525	7820	[illegible]
2012-13		136	1426	8075	[illegible]
2013-14		63	1490	7565	[illegible]
2014-15		134	1426	9005	[illegible]
2015-16		135	1420	6780	[illegible]
2016-17		140	608	9787	[illegible]
2017-18	Kachua Chandpur	141	612	8095	[illegible]
2018-19		137	602	6219	[illegible]
2019-20		144	712	6520	[illegible]
2020-21		141	712	6206	[illegible]
2005-06	Sadar B.Baria	142	3000	13200	[illegible]
2006-07		142	3000	13500	[illegible]
2007-08		130	3207	14226	5.87
2008-09		144	4630	15145	6.37
2009-10		152	4626	18360	6.39
2010-11		105	1818	7091	5.76
2011-12		100	1879	7789	4.88
2012-13		98	1871	7770	5.57
2013-14		101	1858	11585	5.77
2014-15		102	1869	9560	4.98
2015-16		102	1869	8715	5.03
2016-17		101	1369	8579	4.55
2017-18		102	1373	9105	5.38
2018-19		54	1369	8305	5.52
2019-20		57	2359	8525	7.12
2020-21		56	2659	7525	6.4

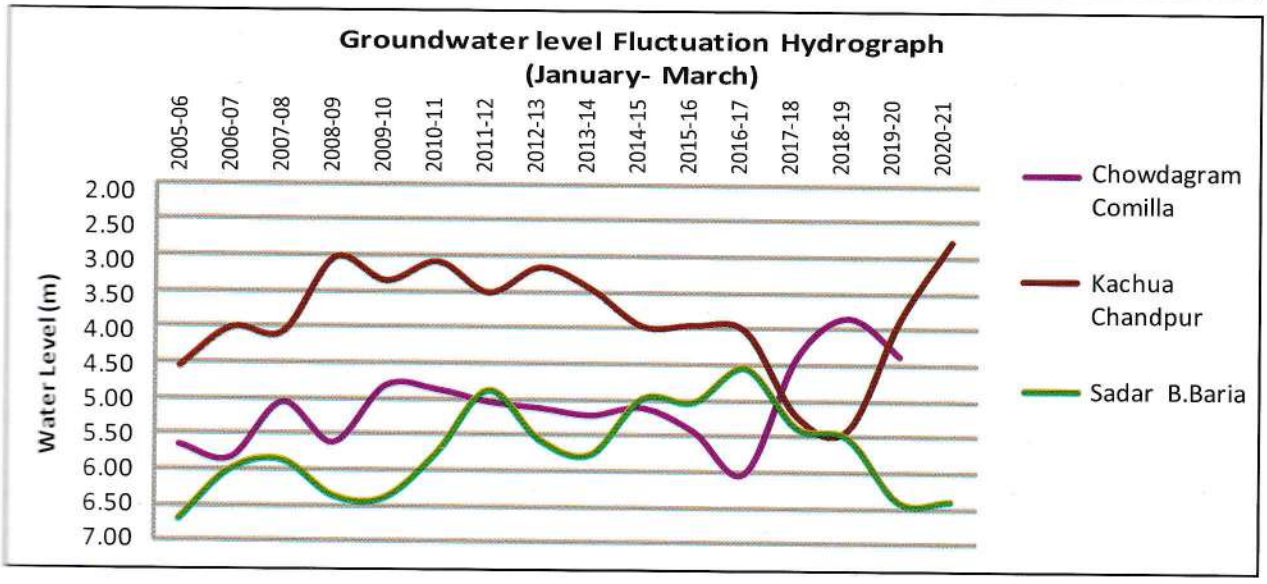


Figure 51:Changes in the depth of groundwater table (Jan-Mar) over time

The figure-51 prepared by the maximum depth of groundwater table over the last 15 years (2006-2021) is indicating the fluctuation of groundwater table in the South-Eastern region of Bangladesh. The hydrograph implies that in the dry period (January-March), all the upazila's water level was within the range of the suction lift pump to tap the water for irrigation.

FINDINGS OF THE SURVEY

The main objective of this survey was to find out the number of operated different irrigation equipment, area irrigated and beneficiaries. BADC, DAE and BMDA field staffs are collected the above irrigation equipment information's. We know that, the accurate area calculation was quite difficult, because there was no specific method to calculate the area. So, the information's was collected from the statement of the equipment's owners and consultation with beneficiary farmers. It is mentioned that the irrigated area per equipment may vary from location to location as well as farmer to farmer.

The main findings of this survey report are:

- ★ During this irrigation season 2020-21 the operation of deep tube wells decreased by 0.14% shallow tube wells and low lift pumps increasedby 0.785% and 2.23% respectively which is significant in comparison with the previous year.
- ★ In the 2020-21 Rabi season, total irrigated area was 5654789 hectares, of which groundwater irrigation covered 4108254 hectares, 72.65% of the total irrigated area; while surface water irrigation covered 154653 hectares and 27.35% of total irrigated area.To comparison with the previous year which is indicates that using of groundwater in irrigation activities is discouraging significantly in boro season.
- ★ The irrigated area during this Rabi season increased by 0.48% than that of the previous year 2019-20. The area under DTW decreased by 0.11%, STW isincreased by 0.12% and LLP also increased by 1.37% which is acceptable.
- ★ It is found that about 94.86% (35059) DTWs were operated by electric motors and 5.13% (1896) DTWs were operated by diesel engines. In case of shallow tube wells, 26.83% (378225) STWs were operated by electric motors and 73.16% (1031464) STWs were operated by diesel engines. Low Lift Pumps were mainly operated by diesel engines, which is 90.23% (184429) and the rest were operated by electric motors which is only 9.70% (19962).
- ★ The average irrigated area per DTW was 29.37 hectares, per STW was 2.13 hectares and per Low Lift Pump was 6.30 hectares.
- ★ The price of rice determines future investment to a considerable degree. The producer/farmers will be encouraged to invest in irrigation sector if the Boro price goes up unusually.
- ★ It is very essential to strengthen survey and monitoring activities by providing enough skill manpower for collecting and analyzing irrigation related data which will help Government for taking future plan & program.

Organization Wise Summary of Irrigation Equipment Used, Area Irrigated and Benefited Farmers Rabi Crops (Boro, Wheat, Potato, Maize, Onion and Vegetables) 2020-21

Type of Equipment	Name of organization	Operated by Electricity					Operated by Diesel			Total		
		Unit			Irrigated Area (ha)	Benefitted Farmers	Unit	Irrigated Area (ha)	Benefitted Farmers	Unit	Irrigated Area (ha)	Benefitted Farmers
		PDB	REB	TOTAL								
DTW	BADC	879	10142	11021	324448	1175589	932	21642	56335	11953	346090	1231924
	BMDA	962	14575	15537	512064	962474	0	0	0	15537	512064	962474
	Others	953	7548	8501	215635	811550	964	11642	102634	9465	227277	914184
	Total	2794	32265	35059	1052147	2949613	1896	33284	158969	36955	1085431	3108582
STW	BADC	15	141	156	768	2510	11	55	296	167	823	2806
	BMDA	0	0	0	0	0	0	0	0	0	0	0
	Others	33821	344248	378069	1044126	3479135	1031453	1961125	9375253	1409522	3005251	12854388
	Total	33836	344389	378225	1044894	3481645	1031464	1961180	9375549	1409689	3006074	12857194
LLP	BADC	288	2649	2937	65725	156520	5594	142563	165235	8531	208288	321755
	BMDA	29	393	422	12413	22545	0	0	0	422	12413	22545
	Others	3214	13389	16603	183789	557356	178835	882523	2649356	195438	1066312	3206712
	Total	3531	16431	19962	261927	736421	184429	1025086	2814591	204391	1287013	3551012
DTW +STW +LLP		40161	393085	433246	2358968	7167679	1217789	3019550	12349109	1651035	5378518	19516788
Manual & Artesian Well		0	0	0	0	0	0	0	0	0	6752	29455
Traditional Method		0	0	0	0	0	0	0	0	0	6124	22789
Gravity Flow		0	0	0	0	0	0	0	0	0	245136	274056
Solar Pump		0	0	0	0	0	0	0	0	4523	16524	45236
Dug Well		0	0	0	0	0	0	0	0	555	1735	2135
COUNTRY TOTAL		40161	393085	433246	2358968	7167679	1217789	3019550	12349109	1656113	5654789	19890459

(Md. Abdur Rashid)
Executive Director, BMDA
Tele : 0721-761368

(Md. Asadullah)
Director General, DAE
Tele : 55028369

(A F M Hayatullah)
Chairman, BADC
Tele : 223384358