IRRIGATION AND AGRI-FOOD SECURITY IN PURULIA – A BACKWARD DISTRICT OF WEST BENGAL, INDIA

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INTRODUCTION

Purulia, a socio-economically backward district having geographical area of 6259square kilometer (sqkm) is located in southwest of West Bengal, India. The Human Development Index (HDI) of Purulia district is 0.45 (Rank-16 in West Bengal) (www.wbplan.gov.in). Out of the 2468 numbers of rural inhabited Mouzas, 994 numbers (40.28%) of Mouzas has been declared as backward in this district (www.puruliazp.in). Agriculture is the main source of livelihood of the inhabitants of Purulia district. The draught is accentuated due to high evaporation loss, rapid surface run off, inadequate storages and low moisture retention capacity of light textured soil in whole area of the district (Halder, 2011). The major part of the district is characterized with undulating topography. The soil is light textured with high porosity and poor water holding capacity. Due to continuous erosion of soil micronutrient deficiency is common in upland and medium high land situation (MoA, GoI). The crop-water requirements are hardly met through rainwater and irrigation water due to acute water scarcity during summer in almost every year. Thus enhancing irrigation facilities for food security of the growing population in Purulia district is a big challenge.

PHYSIOGRAPHY AND CLIMATE

The Purulia district, extension of Chotonagpur Plateau lies in the south-western part of the state of West Bengal lies between 22º42'35" N and 23º42'00" N latitudes and 85º49'25" E and 86º54'37" E longitudes covering 6259sqkm. The Purulia district is sub-divided into 20 numbers of administrative blocks. The district is characterised by undulating topography with rugged hilly terrain in western and southern part. The master slope of the land surface is being towards east and south-east. Physiographically the district can be sub-divided into two distinct units. The one is hilly terrain in the western and south-western part, where *Ajodhya Pahar*, *Gargaburu*, *Raika Pahar*, *Churni Pahar*, *Aral Dungri* and *Gurma Pahar* are some important hills. The other one is the undulating plain with isolated mounds and hills namely, *Panchet hill*, *Tilaboni*, *Ramchandrapur*, *Barberia*, *Jaichandipahar*, *Maguria* etc., which comprises of seventy percent of the total area of the district. The top soil cover in almost

entire district is thin gravelly and acidic. The district is underlain by Pre-cambrian metamorphics except in a small area in northeastern part; where sedimentary of Gondowana age predominate. Unconsolidated sediments of recent to sub-recent age are restricted to the narrow river channels and to the valleys. The most common rocks of widespread occurrence in the district are granites and granite gneisses.

The district experiences very hot summer and moderately cold winter. The temperature varies from 48ºC to 5ºC. Evapo-transpiration rate in the district is high due to bright sunshine and flow of hot waves. The average annual rainfall in the district is 1250mm (thirty years' average). The district receives bulk of rainfall through south-west monsoon during June to September. But the major portion of monsoon rainfall is lost by the quickly flowing surface run off over the terrain having moderate to high slope.

AGRICULTURE AND IRRIGATION

Total cultivable area in Purulia district is about 444525ha (2004-2005) (WBSMB, GoWB). Most of the arable lands of the poor people in the district are mono-cropped (Chakraborty). Cropping Intensity (C.I.) is about 117% (www.puruliazp.in) in Purulia district. About 90% of net cropped area is under *Aman* paddy cultivation and other major crops are wheat, pulses, oilseeds, sugarcane, potato etc.; fruit crops are mango, papaya, banana, pineapple, guava etc.; vegetable crops are brinjal, cucurbits, tomato, cabbage, ladies finger etc. in this district. *Aus* paddy is cultivated mainly in Manbazar-II. Barabazar, Balarampur and Purulia-I block. *Boro* paddy cultivation is practiced mainly in Manbazar-II, Arsa, Bandowan and Puncha block. Cultivation of paddy is maximum in Manbazar-II block. All three seasonal paddy cultivations e.g. *Aus* (summer), *Aman* (winter) and *Boro* (spring) have been practiced only in five numbers of blocks namely Balarampur, Manbazar-II, Manbazar-I, Purulia-I and Puncha. Therefore, paddy cultivation in Purulia district is comparatively more in its southeastern part. The yield rates of major fodder crops like Rice, Wheat and other Cereals during the last three years are shown in Figure 1.

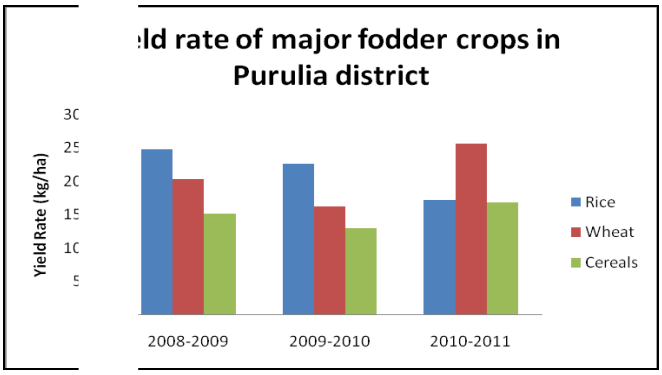


Figure 1 Yield rate of major fodder crops in Purulia district.
(*Data Source*: Department of Statistics & Programme Implementation, Government of West Bengal)

In Purulia district about 24885 ha (2009-2010) area is irrigated by 26 numbers Canal Irrigation schemes and 46009 ha (2006-2007) area is irrigated by 17897 numbers Minor Irrigation schemes (e.g. Dug Well, Shallow Tube Well, Surface Flow and Surface Lift schemes), thus irrigating about 16% cultivable area in a year (Table 1). As per data of West Bengal State Marketing Board (WBSMB), Government of West Bengal, four numbers of blocks namely, Manbazar-I, Puncha, Raghunathpur-I and Neturia in Purulia district are deprived from the Canal Irrigation facilities and the only source of irrigation in theses blocks is Minor Irrigation from Dug Wells, Surface flow and Surface Lift schemes.

Table 1 List of Irrigation Schemes in Purulia District

Sl. No.	Irrigation Schemes	Total Irrigated Area in a year (ha)
(A) Medium (CCA- 2000-10,000ha) & Minor (CCA<2000ha) Canal Irrigation Schemes (2009-2010) (I&WD, GoWB, 2012)		
1	*Kumari* Irrigation Scheme	3439
2	*Saharajore* Irrigation Scheme	2631
3	*Bandhu* Irrigation Scheme	2455
4	*Barabhum* Irrigation Scheme	2084
5	*Hanumata* Irrigation Scheme	1737
6	*Ramchandrapur* Irrigation Scheme	1678
7	*Dangra* Irrigation Scheme	1410
8	*Lipaniajore* Irrigation Scheme	1260
9	*Rupai* Irrigation Scheme	1214
10	*Turga* Irrigation Scheme	788
11	*Kestobazar* Irrigation scheme	769
12	*Taragonia* Irrigation Scheme	700
13	*Khairabera* Irrigation Scheme	576
14	*Parga* Irrigation Scheme	526
15	*Dimu* Irrigation Scheme	480
16	*Tara* Irrigation Scheme	447
17	*Kulbera* Irrigation scheme	398
18	*Bandajore* Irrigation Scheme	385
19	*Majra* Irrigation Scheme	355
20	*Moutojore* Irrigation Scheme	355
21	*Kansai* Irrigation scheme	290
22	*Sankha* Irrigation Scheme	279
23	*Karrior* Irrigation Scheme	243

24	*Fuljore* Irrigation scheme	185
25	*Fakidi* Irrigation scheme	146
26	*Buridumur* Irrigation Scheme	55
TOTAL (A) (26 nos.)		**24885**
(B) Minor Irrigation Schemes (2006-2007) (DWRI&D, GoWB, 2012)		
1	*Surface Flow* Irrigation Schemes (13732 numbers)	42083
2	*Surface Lift* Irrigation Schemes (539 numbers)	2638
3	*Dug Well* Irrigations Schemes (3611 numbers)	1283
4	*Shallow Tube Well* Irrigation Schemes (15 numbers)	5
TOTAL (B) (17897 numbers)		46009

GROUNDWATER IRRIGATION

Groundwater in Purulia district occurs mainly in weathered mantle, saprolitic zone, fractured zones of hard rock and narrow zone of unconsolidated sediments along river valleys (Figure 2). The weathered mantle attains a maximum thickness of 25m. Groundwater occurs under water table condition and it is mostly developed by dug/bore wells yielding upto 2.75litre per second (lps). The saprolitic zone is sandwiched between weathered mantle and fresh rock mass in granitic terrain. The depth of this zone varies between 10 to 30m below ground level (mbgl) with an average thickness of 4m. Drawdown in the well tapping this zone is much less and recovery is quite fast.

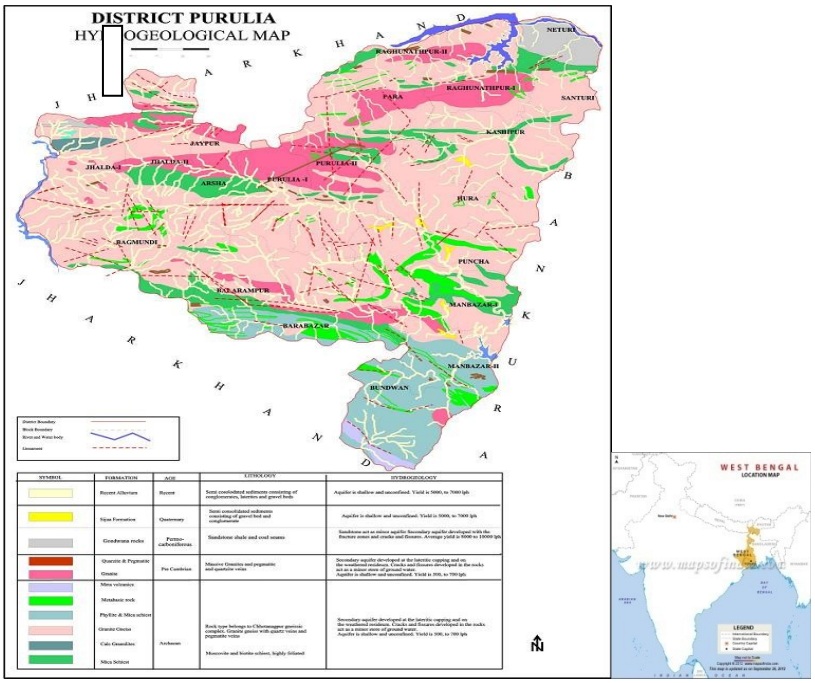


Figure 2 Hydro-geological map of Purulia district
(*Source*: CGWB, GoI)

In hard rock, groundwater exploration has been conducted from shallow saturated fractures encountered at 50 to 110m bgl. The shallow fractures encountered at 50 to 60m depth are tapped mainly through bore wells yielding 1.00 to 2.77lps and the deeper fractures encountered at 100 to 110m depth are tapped in Gondowana sediments yielding around 3.00 to 5.50lps. Unconsolidated sediment zones along river valleys are of limited thickness and fall within 5 to 13m bgl with areal extent not exceeding 1 to 2km across river valley. Saturated thickness of alluvial tract varies from 1.0 to 5.5m. Open wells and shallow tube wells yield upto $20m^3$/hr at economic drawdown for a considerable period of pumping (CGWB). Groundwater can be exploited in the district generally through Dug Well upto 20m, Dug cum Bore Well at 20 to 40m bgl and Bore Well upto 80m yielding 0.88 to 2.75lps. In Gondowana rocks in the northern portion of Santuri and Neturia block, Dug Wells encountered at fractures within depth of 24-26m bgl yields 3.30 to 5.50lps. Seventeen numbers of Exploratory Tube Wells having discharge 0.33 to 6.64lps in the depth range 30.30 to 183.42m have been sunk by the Central Ground Water Board, Eastern region (CGWB, ER) in different groundwater prospecting fracture zones in Purulia district.

Groundwater occurs in unconfined to semi-confined condition at shallow depth and saturated fractures at deep in the entire district. Average pre-monsoon and post-monsoon depth to ground water level ranges from 4.00 to 11.50m below ground level and 2.00 to 5.50m below ground level respectively. The average water level fluctuation is restricted within 2.00 to 6.00m and no abnormal rise or fall in groundwater level has been observed in decadal groundwater level trend in all blocks of the district.

Net annual dynamic groundwater resources availability in Purulia district has been estimated as 0.75Billion Cubic Metre (BCM) (2008-2009). The stage of groundwater development in the district is computed as 7%. Annual gross groundwater draft for irrigation has been estimated as 0.01BCM and the same for domestic and Industries has been estimated as 0.04BCM. The net groundwater available for future irrigation development in the district has been computed as 0.70BCM (allocating 0.05BCM for domestic and industrial use upto 2025) (CGWB, 2011).

As per Fourth Minor Irrigation Census (2006-2007) by Department of Water Resources Investigation & Development (DWRI&D), Government of West Bengal (GoWB) about 1283ha area is irrigated by 13611 numbers Dug Well

Minor Irrigation schemes and about 5ha area is irrigated by 15 numbers Shallow Tube Well Minor Irrigation schemes using groundwater resources in Purulia district (Figure 3). Therefore, groundwater utilization in irrigation is very less in Purulia district for problem associated with drilling/digging of Tube/Dug Well due to existence of hard rock at shallow depth. But still there is further scope in development of groundwater for irrigation by construction of Tube/Dug wells at groundwater prospecting weathered fractures and river valleys in Purulia district. At some places these wells go dry during peak summer. The groundwater availability in these water scarce pockets can be increased through Managed Aquifer Recharge (MAR) - a process of purposeful recharge of water to aquifers under controlled conditions for later use. Spreading Recharge method has been applied through construction a good numbers of Percolation Tanks in a few blocks of Purulia district by the State Water Investigation Directorate (SWID) under Department of Water Resources Investigation & Development (DWRI&D), Government of West Bengal (GoWB).

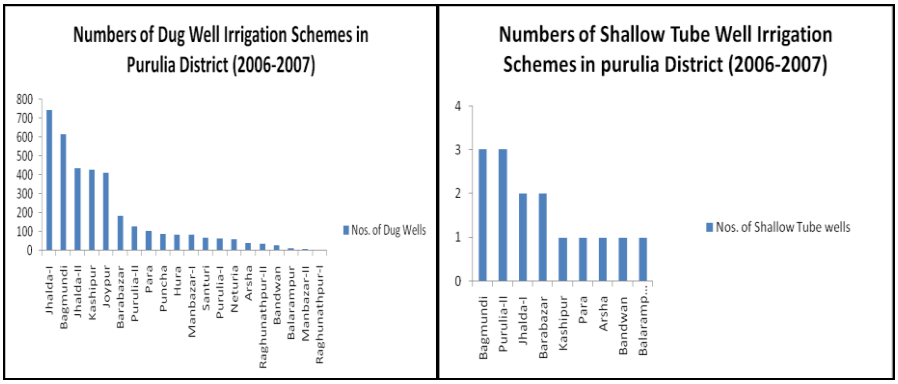


Figure 3 Groundwater Minor Irrigation Schemes in Purulia district

(*Data Source*: Report of Fourth Minor Irrigation Census (2006-2007), DWRI&D, 2012)

Groundwater in Purulia district is neutral to slightly alkaline (pH- 7 to 8.2). As per groundwater quality surveyed by Public Health Engineering Department (PHED), Govt. of West Bengal (GoWB) Fluoride in groundwater has been detected in almost all blocks (17 numbers) in Purulia district (Figure 4) except Jhalda-II, Bundowan and Manbazar-II block. Flouride beyond recommended maximum concentration in irrigation water i.e. 1.0 mg/lt (FAO) has been detected in groundwater samples at 1192 numbers of Tube Wells in 17 numbers of blocks in Purulia district (PHED, GoWB). Therefore, groundwater development for Irrigation nearby these sampling Tube Wells should be done

cautiously to avoid migration of fluoride through food chain, which may cause dental and skeletal *fluorosis*.

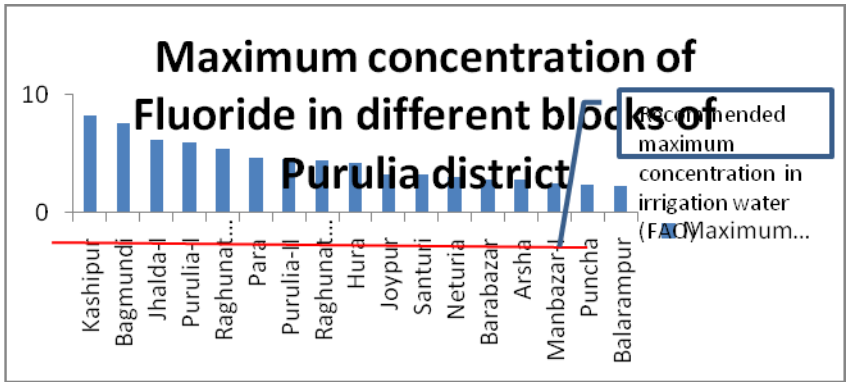
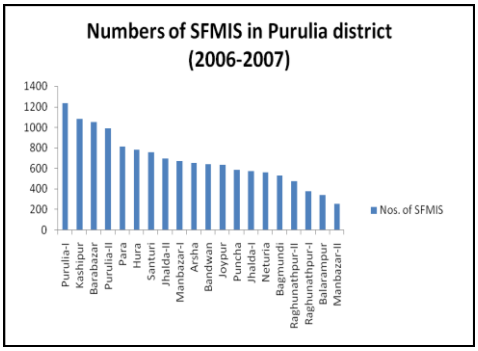
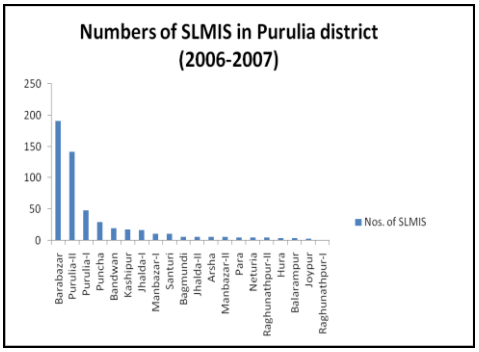


Figure 4 Maximum concentration of Fluoride in groundwater in different blocks of Purulia district.(*Data Source*: http://www.wbphed.gov.in/main/Static_pages/Fluoride_Reports/FLBlockwise_A4.pdf)

SURFACE WATER IRRIGATION

The district drains by seven main rivers namely *Kangsabati*, *Shilabati*, *Darakeswar*, *Kumari*, *Damodar*, *Subarnarekha* and *Tatko* and its tributaries in dendritic pattern from northwest to southeast. Out of these seven rivers, *Kangsabati*, *Shilabati*, *Darakeswar* and *Kumari* originate from hilly terrain inside Purulia district. During summer discharge of almost all the rivers except *Damodor*, *Kangsabati* and *Subarnarekha* become very low. There are a few small streams having flows only in rainy season namely *Nengsai*, *Hanumata*, *Sona*, *Beko*, *Utla*, *Panrga*, *Shalda*, *Rupai*, *Patlai*, *Bandu*, *Chaka*, *Jam*, *Karru*, *Shobha*, *Kudlung*, *Shakha*, *Toser Kuo*n, *Harai*, *Guai*, *Kadamda*, *Patloi*, *Tara*, *Amru Hasa* and *Kenrro* originating from different hilly terrains in western part of the Purulia district. Annual assured surface water resources availability in Purulia district has been estimated as 3.68BCM (WBPCB, 2009). Surface water quality in Purulia district is suitable for irrigation. As per Annual Report 2010-2011 of Irrigation & Waterways Department (I&WD), Government of West Bengal (GoWB) about 24288ha area (2009-2010) is irrigated by 26 numbers Medium and Minor Canal Irrigation schemes. As per report of Fourth Minor Irrigation Census (2006-2007) of Department of Water Resources Investigation & Development (DWRI&D), Government of West Bengal (GoWB) about 42083ha area is irrigated by 13732 numbers Surface Flow Minor Irrigation Schemes (SFMIS) and about 2638ha area is irrigated by 539 numbers Surface Lift Minor Irrigation Schemes (SLMIS) using surface water resources in Purulia district (Figure 5).





(*Data Source*: Report of Fourth Minor Irrigation Census (2006-2007), DWRI&D, 2012)

Also, there are 22704 numbers of Water Tanks (Surface Water Bodies) of which, 14044 numbers of Water Tanks (62%) are being used for Irrigation purpose in Purulia district (Figure 6).

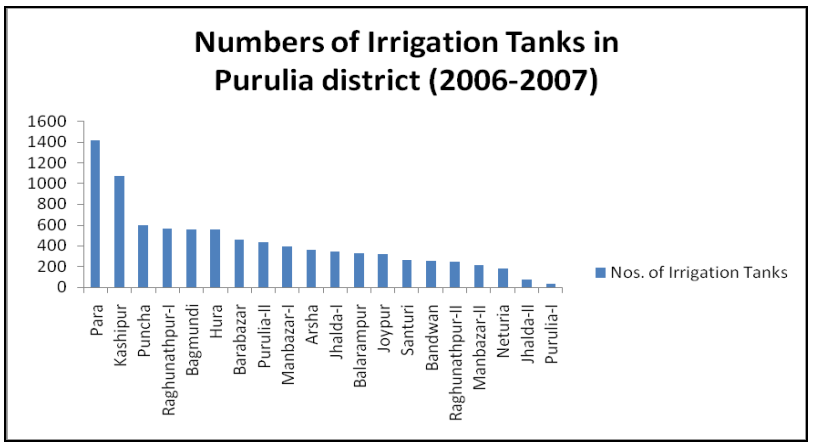


Figure 6 Irrigation Water Tanks in Purulia district

(*Data Source*: Report of Fourth Minor Irrigation Census (2006-2007), DWRI&D, 2012)

The Government of West Bengal has carried out Mahatma Gandhi National Rural Employment Guarantee Act (MGNREGA), a Government of India (GoI) programme having two fold actions; firstly, provision of rural employment through excavation of earth, re-excavation of tanks, rising embankments, development of jorebunds etc. for immediate benefit and secondly, special care has been taken to increase rainwater storage potential in backward areas of Purulia district, so as to enhance the agricultural activities as a permanent source of employment. This work has been mobilized by the *'Jal Dharo Jal bharo'* (Preserve Water, Reserve Water) initiatives by the Department of Water Resources Investigation & Development (DWRI&D), Government of

West Bengal (GoWB). Also, schemes of soil conservation, digging wells and land reclamation have been taken up to tackle the situation. This has improved the socio-economical situations in this district to some extent. A few number of Jors (natural depressions, where surface run off accumulated) in Purulia district, which can be utilized for irrigation through construction of *Jor Bunds*, which are tabulated in Table 2.

Table 2 List of Jors in Purulia district (Roy, 2007)

Sl. No.	Name of Jor	Location/ Thana	Sl. No.		Location/ Thana
1	Bandar Jor	Banda	13	Fatepur Jor	Para
2	Basarrar	Basrara	14	Kulberia	Baghmundi
3	Tulsibari Jor	Tulsibari	15	Taragalia Jor	Purulia
4	Karapancha Jor	Moutor	16	Golmara Jor	Purulia
5	Ramchandrapur Jor	Murabari, Ramchandrapur	17	Muguma Jor	Jhalda
6	Jamuna Jor	Purulia	18	Lipania Jor	Lipania
7	Paita Jor	Puncha	19	Chakbarahira Jor	Usir, Hadla
8	Futihari Jor	Hura	20	Tilhir Jor	Kashipur
9	Sahar Jor	Jhalda	21	Kestobazar Jor	Baghmundi
10	Fakidi Jor	Jhalda	22	Kairabera Jor	Baghmundi
11	Shankha Jor	Balarampur	23	Turga Jor	Baghmundi
12	Fuljharna Jor	Arsha	24	Rukni Jor	Rukni
			25	Dubra Jor	Para, Dubra

There are a few small Bandhs already constructed in different places in Purulia district, which are listed in Table 3 (Roy, 2007).

Table 3 List of Bandhs in Purulia district

Sl. No.	Name of Bandh	Location/ Thana	Sl. No.	Name of Bandh	Location/ Thana
1	Bero Bandh	Bero	11	Harishchandra Sayer Bandh	Janardandi, Neturia
2	Natun Bandh	Ketika	12	Jamadar Bandh	Kashipur
3	Morol Bandh	Rajnowagor, Kenda	13	Rani Bandh	Joypur
4	Goala Bandh	Jambaid, Kenda	14	Mishri Bandh	Balarampur
5	Shyam Bandh	Cheliama, Raghunathpur	15	Raj Bandh	Jhalda
6	Bara Bandh	Khatchiri, Manbazar	16	Ghosal Bandh	Kanra, Puncha
7	Sarkar Bandh	Jambaid, Kenda	17	Kalupukur Bandh	Bagda, Puncha
8	Sayer Bandh	Maheshpur, Kenda	18	Shikari Bandh	Gopalpur, Manbazar
9	Bara Bandh	Raghunathpur	19	Lekuria Bandh	Moutar, Raghunathpur
10	Dakai Bandh	Budhpur, Puncha	20	Jaba Bandh	Barabazar
			21	Shunri Bandh	Hura

WATER USE EFFICIENCY MANAGEMENT

Water Use Efficiency (WUE) is very important in crop production and irrigation water management (Majumdar, 2009). Purulia is a drought prone district, where temperature is very high in summer and low in winter varying from 3.8ºC in winter to 52ºC in summer, which causes dryness in moisture. Average annual rainfall varies between 1100 and 1500 mm, but uneven, scanty and erratic rainfall often creates drought-induced agri-food production crisis during kharif season in this district. Therefore, Water Use Efficiency management in irrigated agriculture is very much essential in connection with food security in a semi-arid district like Purulia. Water use efficient cultivation and irrigation practices are very fruitful for WUE management in agricultural field. Also, crops having high water use efficiency coupled with a higher rate of photosynthesis like sugarcane, maize, sorghum, millets, amaranthus etc. can be cultivated suitably in Purulia district.

Water Use Efficient Cultivation

Recently, the System of Rice Intensification (SRI) paddy cultivation methodology has been successfully implemented in different parts in Purulia district by the effort of Department of Agriculture (DoA), Government of West Bengal (GoWB) and different Non-Government Organisations (NGO). System of Rice Intensification (SRI) was developed in Madagascar and popularised in the 1980s by Father Henri de Laulanie, a French priest. It is claimed that SRI has a great potential in addressing the major challenges confronting India - food security and water crisis (NABARD).

SRI has the following eight basic principles (NABARD):

- Preparing high-quality land.
- Developing nutrient-rich and un-flooded nurseries (Figure 7).
- Using young seedlings for early transplantation (Figure 8).
- Transplanting the seedlings singly and not multiple as it is done in non-SRI Transplantation.
- Ensuring wider spacing between seedlings.
- Preferring compost or farmyard manure to synthetic fertilisers.
- Managing water carefully so that the root zones of plants are moistened, but not continuously saturated.
- Deweeding frequently.

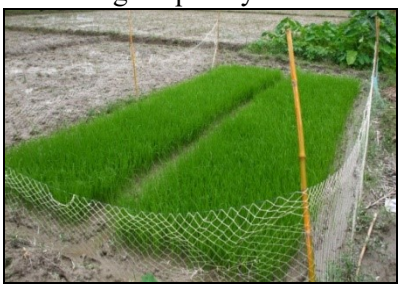


Figure 7 Preparation moist lands for nursery-bed

Figure 8 Young Seedlings for early transplantation

The basic practices of SRI according to SRI-Rice at Cornell University are (Wikipedia.org):

- Rice plant seedlings should be transplanted very young (usually just 8-12 days old) with just two small leaves.
- Seedlings should be transplanted carefully and quickly to inflict minimum trauma on the roots.
- Seedlings should be transplanted singly, with only one per hill instead of 3-4 together to minimize root competition.
- Seedlings should be widely spaced to encourage greater root and canopy growth.
- Seedlings should be transplanted in a square grid pattern (25x25 cm, or wider in good quality soil)

Characteristics of SRI with respect to water use (NABARD):

- The SRI improves yields with less water, less seed, and less chemical inputs than most conventional methods of rice cultivation. This means that the returns on inputs are higher, making the method potentially more profitable than most of the traditional methods.
- SRI improves the productivity of land, labour, water and capital used in rice cultivation.
- It is more resistant to biotic and abiotic stress beside drought.

Water Use Efficient Irrigation

The use of modern irrigation technique like Drip irrigation may become an alternative for efficient use of available water resources. Drip irrigation, which is also known as trickle irrigation or micro irrigation, is the application of the irrigation water, drop by drop, at the rate of consumptive water use of the crop. The system mainly consists of plastic (PVC) pipes laid on the ground or buried at shallow depth. Water is conveyed to the crops through these pipes and water is delivered to the crop by the emitters, placed at near to the crop. There is a pumping unit attached with the irrigation system, which lift the water from the nearby water sources e.g. Water Tank, Dug/Bore Well, River etc. and deliver to the crops at desired pressure (Figure 9). Drip irrigation can play a vital role in the water management to ensure water security thereby enhancing food security. The research says that it not only reduces the agricultural water consumption but also increases the agricultural production. In Drip irrigation technique water mixed with fertilizer is delivered directly to the roots of plants, thereby improving soil moisture conditions. In some studies, this

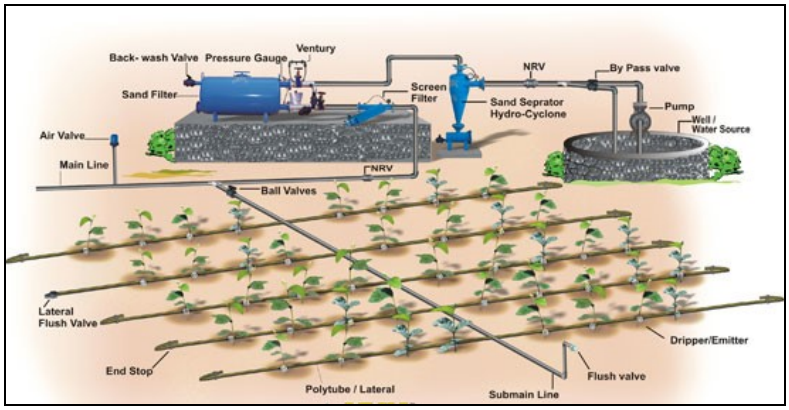


Figure 9 A model design of Drip irrigation system
(*Source:* http://www.jains.com/irrigation/drip%20irrigation%20system.htm)

has resulted in yield gains of up to 100%, water savings of up to 40–80%, and associated fertilizers, pesticides, and labor savings over conventional irrigation systems. Therefore, drip irrigation is the most appropriate water management technology to sustain and enhance vegetable food production in drought prone Purulia district. In many parts of the district, there is acute shortage of electricity and solar powered motor-pump is a feasible solution for drip irrigation in those areas.

CONCLUSIONS

As low flow occurs during summer in almost all rivers/streams, there is a limited scope to take up more Canal and/or Surface Flow/Lift irrigation schemes in Purulia district. Also, Dug/Tube Well irrigation facility is limited only at weathered fracture zones. But, there is ample scope to enhance small scale irrigation facilities by construction of more numbers of lined/unlined Water Tanks in which rain water can be harvested for use of it to irrigate agricultural lands. Jor Bund at natural depression land is also a feasible option for small scale irrigation in the district. But it can be said that the existing Major and Minor irrigation status with the availability of both the surface water and groundwater can be managed to some extent through efficient water use practices like SRI, Drip irrigation and cultivation of low water use crop, to ensure the agri-food security for the people of Purulia district. Consequently, formation of Water Users Associations (WUA) with the provision of Capacity Building and Training for the members of WUA is very much essential to achieve efficient water management in irrigated agriculture vis-à-vis high agri-food productivity.

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