BANCID

Yearly Newsletter 2017

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BANGLADESH NATIONAL COMMITEE OF THE INTERNATIONAL COMMISSION ON IRRIGATION AND DRAINAGE (BANCID)

World Water Day 2017 was observed on 22 March 2017

The World Water Day 2017 was observed all over the country on 22 March, 2017. The Ministry of Water Resources in association with other organizations/ departments organized a rally to observe the day and after the rally a discussion meeting was held at Bangabandhu International Conference Center (BICC). Mr. Anisul Islam Mahmud, MP, Honourable Minister, Ministry of Water Resources, Government of the People's Republic of Bangladesh graced the occasion as Chief Guest. Mr. Muhammad Nazrul Islam, Bir Protik, MP, Honourable State Minister, Ministry of Water Resources, Government of the People's Republic of Bangladesh and Mr. Md. Abul Kalam Azad, Principal Coordinator (SDG Affairs), Prime Minister's Office attended the discussion meeting as Special Guests. The discussion meeting was chaired by Dr. Zafar Ahmed Khan, Senior Secretary, Ministry of Water Resources, Government of the People's Republic of Bangladesh. A video clip on Water Resources Management of Bangladesh was presented in the meeting. A Special Supplement was also published in well circulated national dailies on 22 March, 2017.

On the occasion of the World Water Day 2017, Bangladesh National Committee of the International Commission on Irrigation and Drainage (BANCID) organized a Seminar on Wastewater under the guidance of Ministry of Water Resources in association with Bangladesh Water Development Board (BWDB), Institute of Water Modelling (IWM) and Center for Environmental and Geographic Information Services (CEGIS) at the Conference Room of Bangladesh Water Development Board, WAPDA Building, Motijheel C/A, Dhaka on 28 March 2017. Eminent water experts and engineers from different government and non government organizations, academicians and representatives from NGO's attended the seminar.

Seminar for the World Water Day 2017 on 28 March 2017

Mr. Muhammad Nazrul Islam, Bir Protik, MP, Honorable State Minister, Ministry of Water Resources, Government of the People's Republic of Bangladesh graced the occasion as Chief Guest. Dr. Zafar Ahmed Khan, Senior Secretary, Ministry of Water Resources, Government of the People's Republic of Bangladesh attended the seminar as Special Guest. The Seminar was chaired by Mr. Md. Jahangir Kabir, Director General, Bangladesh Water Development Board and Chairman, BANCID.

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Yearly Newsletter 2017
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BANGLADESH NATIONAL COMMITTEE OF THE INTERNATIONAL COMMISSION ON IRRIGATION AND DRAINAGE

Editorial

The Publication of Annual Newsletter of Bangladesh National Committee of the International Commission on Irrigation and Drainage (BANCID) is an extraordinary initiative taken by the Study and Publication Sub-Committee of BANCID. The aim of this publication is to disseminate information on the activities of BANCID and to receive feedback from the concerned communities.

In this sixth issue of the newsletter, write ups/articles on water related issues have been included. We are thankful to the contributors/organizations for submitting the write ups/articles. We will be very much grateful to receive comments and suggestions if any from the concerned organizations on our initiative of publishing this newsletter.

The composition of the present Study and Publication Sub-Committee is as follows:

BANCID Study and Publication Sub-Committee

1.	Dr. M. Shahjahan Mondal, Professor, IWFM, BUET	Convenor
2.	Mr. Moshiur Rahman, Secretary General, BWP	Member
3.	Mr. Md. Mofazzal Hossain, Member, JRC	Member
4.	Mr. Md. Ziaul Haque, Chief Engineer (Minor Irrigation), BADC	Member
5.	Dr. Nazmun Nahar Karim, Chief Scientific Officer (Addl. Charge), BARC	Member
6.	Mr. Fazlur Rashid, Director, Planning-1, BWDB	Member
7.	Dr. K. M. Ahtesham Hossain Raju, Assistant Professor, Department of Water Resources Engineering, BUET, Dhaka.	Member
8.	Dr. Robin Kumar Biswas, Executive Engineer, BWBD, Dhaka	Member
9.	Engr. Md. Year Khan, Executive Engineer, Dhaka WASA, Dhaka.	Member
10.	Mr. Abu Saleh Khan, Deputy Executive Director (Operation), IWM	Member
11.	Mr. Malik Fida A. Khan, Deputy Executive Director, CEGIS	Member
12.	Dr. Md. Atikur Rahman, Professor, Department of Irrigation & Water Management, BAU	Member
13.	Dr. Ali Muhammad Omar Faruque, Deputy Director (Agriculture, Fisheries and Environmental), DBHWD, Dhaka	Member
14.	Mr. Mohammad Alamgir, Principal Scientific Officer (EF and F), WARPO	Member
15.	Dr. Moniruzzaman Khan Eusufzai, Senior Scientific Officer, RRI	Member
16.	Mr. Noman Hyder, Sub-Divisional Engineer, JRC	Member
17.	Mr. Md. Mahmudur Rahman, Director, JRC and Member Secretary, BANCID	Member -Secretary

From Member Secretary's Desk

ACTIVITIES OF THE BANGLADESH NATIONAL COMMITTEE OF THE INTERNATIONAL COMMISSION ON IRRIGATION AND DRAINAGE (BANCID)

The International Commission on Irrigation and Drainage (ICID) was established in 1950 with the objective of promoting technical, economic and social cooperation with regards to irrigation and drainage. In 1957, the ICID's mandate was extended to cover flood control and river training. Bangladesh became member of ICID in 1973. BANCID was constituted under the Ministry of Water Resources since its establishment. The members of BANCID are appointed from different organizations actively engaged in the field of irrigation, drainage, flood control, river training works and other water related activities including one representative from Ministry of Water Resources. BANCID holds national and international seminars in Bangladesh. BANCID also observes World Water Day on 22 March every year since 1993.

On the occasion of the World Water Day 2017, BANCID organized a seminar on 28 March 2017. Two key note papers related to the theme of the Seminar Wastewater were presented in the seminar, one by Dr. Md. Mujibur Rahman, Professor, Department of Civil Engineering, Bangladesh University of Engineering and Technology (BUET) and the other by Engr. Taqsem A Khan, Managing Director, Dhaka Water Supply & Sewerage Authority (WASA).

Four distinguished discussants discussed on the papers presented as well as the theme of the occasion. The designated discussants were (i) Mr. Md. Mahfuzur Rahman, Additional Director General, BWDB, (ii) Dr. Md. Monowar Hossain, Executive Director, IWM, (iii) Engr. Md. Waji Ullah, Executive Director, CEGIS and (iv) Mr. Sharif Jamil, Joint Secretary, Bangladesh Poribesh Andolon. Besides, many participants took part in the open discussions and expressed their valuable comments and observations.

The following observations and recommendations emerged from the Seminar:

1. Increasing awareness among all the people is very much essential so that they do not discharge any type of waste or pollutant into the surrounding rivers, canals and any other water bodies without proper treatment. The concerned authority should take appropriate measures in this regard.
2. Enormous opportunities can be explored from safely managed wastewater and fecal sludge as potentially affordable and sustainable sources of water, energy, nutrients and other recoverable materials.
3. Proper management of wastewater will also provide benefits to human health, economic development and environ mental sustainability- providing new business opportunities and create more 'green' jobs.
4. Awareness building among the vulnerable groups, especially women and children about the risk of partially treated or untreated wastewater is an urgent need.
5. Capacity building and knowledge enhancement of the concerned organizations for improved wastewater management and sanitation are necessary.
6. Sufficient fund should be allocated for improvement of wastewater management system.
7. Urgent steps should be taken by the concerned authority to prevent encroachment and pollution of the rivers of Bangladesh.

BANCID would like to express its sincere thanks to Joint Rivers Commission, Bangladesh for providing necessary fund towards publication of BANCID Newsletter 2017.

BANCID National Committee

From its establishment in 1973, BANCID is actively involved in dissemination of research outcome and news related to irrigation, drainage, climate change and other water related issues both home and abroad. The present 18 member approved Committee (2017-2020) headed by Director General, BWDB is as follows:

1.	**Director General** Bangladesh Water Development Board (BWDB), Dhaka	Chairman
2.	**Head** Department of Water Resources Engineering Bangladesh University of Engineering &Technology (BUET), Dhaka	Vice Chairman
3.	**Dr. M. A. Quassem** Water Expert and Former Director General Water Resources Planning Organization (WARPO), Dhaka	Member
4.	**Director General** Department of Bangladesh Haor and Wetland Development (DBHWD), Dhaka	Member
5.	**Member** Joint Rivers Commission, Bangladesh (JRC), Dhaka	Member
6.	**Director General** Water Resources Planning Organization (WARPO), Dhaka	Member
7.	**Director General** River Research Institute (RRI), Faridpur	Member
8.	**Executive Director** Institute of Water Modelling (IWM), Dhaka	Member
9.	**Executive Director** Centre for Environmental and Geographic Information Services (CEGIS), Dhaka	Member
10.	**Executive Chairman** Bangladesh Agricultural Research Council (BARC), Dhaka	Member
11.	**Head** Department of Irrigation and Water Management Bangladesh Agricultural University (BAU), Mymensingh	Member
12.	**Chief Engineer** Local Government Engineering Department (LGED), Dhaka	Member
13.	**Chief Engineer** Department of Public Health Engineering (DPHE), Dhaka	Member
14.	**Managing Director** Dhaka Water Suply and Sewerage Authority (WASA)	Member
15.	**Chairman** Bangladesh Agricultural Development Corporation (BADC), Dhaka	Member
16.	**President** Bangladesh Water Partnership (BWP), Dhaka	Member
17.	**Deputy Secretary (Administration-2)** Ministry of Water Resources Government of the People's Republic of Bangladesh, Dhaka	Member
18.	**Director** Joint Rivers Commission, Bangladesh (JRC), Dhaka	Member Secretary

Shifting from Boro to Braus paddy cultivation - Option to overcome water scarcity during dry season in Rangpur region

Dr. A B M Zahid Hossain, Senior Scientific Officer, IWM Division, BRRI
Dr. Md. Mahbubul Alam, Senior Scientific Officer, IWM Division, BRRI
Dr.Nazmun Nahar Karim, Chief Scientific Officer (Add. Charge),Agricultural Engineering Unit, Natural Resources Management Division, BARC

Introduction

Land type, climate (temperature, humidity, rainfall), irrigation access and people food habit influences the choice of crops and cropping pattern of an area. Boro (dry season) rice (Oryza sativa L.)-Fallow-T. Aman (monsoon rice) cropping pattern is dominant in Rangpur region of northern Bangladesh, where about 40% of cultivable land is comprised of this pattern. Farmers are growing Boro rice in medium high land by irrigating more than 20 times in a season.Huge groundwater abstraction for Boro rice irrigation in dry season has caused groundwater level depletion in many areas of Rangpur region. As a result, STW irrigation impedes the operation in many areas.Nevertheless with the rising water stress and erratic rainfall, Bangladesh Government has been trying to reduce the Boro rice cultivation in the country for last few years and to provide subsidy for the farmers to encourage producing Aus rice. But the yield of Aus rice is not satisfactory due to pest and disease infestation. Boro rice contributes about 60% of the total food grain production in Bangladesh. Therefore, it is not possible to stop Boro cultivation in Bangladesh suddenly. So we have to find out a pathway how to shift Boro cultivation towards receiving more rainwater in the later part of the growing stage without hampering the food security. So, late Boro or Braus (pre-monsoon season) rice production between Rabi and Kharif II might be an alternate option to save underground water. The present study was undertaken to evaluate the yield performance of Boro rice shifted to Braus as a varietal (BRRI dhan28 and BRRI dhan48) variation and also estimate the water productivity of the Brausin the farmers' field of Rangpur region.

Approaches and Methodologies

Adaptive research has been conducted in three villages namely Nischintopur and Batason Durgapur of Mithapukur, Rangpur and Mondir Durlovkathi of Rajarhat, Kurigram to introduce BRRIdhan48 as test variety as Braus and BRRI dhan28 as widely practiced variety as late Boro or Braus for evaluating the yield performances and water productivity in Rangpur region. Conventional Boro cultivation of some farmer's plots at the same locations were also selected to perform the BRRI dhan28 as widely used Boro variety in the Rangpur region. All the plots except conventional Boro cultivated plots were divided into two equal plots in which each variety (BRRI dhan48 and BRRI dhan28) was transplanted in each farmer's plot. Selected lands were medium-high and the type of soil was light textured. Fertilizer management, cultural practices like weed management, irrigation and pest management were done as and when necessary. Alternate wetting and drying (AWD) technique was applied in the farmer's fields for both the varieties during adaptive trials of Braus. Conventional irrigation method was followed for conventional Boro cultivation.

Results and Discussion

The date of transplanting, seedling age, growth duration and yield of the BRRI dhan28 as conventional Boro at both the locations are shown in Table 1. During Boro trials, 47-51 days old seedlings were transplanted on 18th January to 28thJanuary, 2015 at Kurigram and Rangpur districts, respectively. About 18 to 23 number of irrigation was applied and received 1338 mm to 1452 mm of water for growing Boro in Rangpur and Kurigram districts, respectively.The mean growth duration of BRRI dhan28 in Rangpur and Kurigram was 142 and 143 days, respectively. The average yield of BRRI dhan28 was obtained 6.04 t/ha and 5.81 t/ha in Rangpur and Kurigram districts, respectively. Table 1 also indicates that irrespective of locations the average yield of BRRI dhan28 was 5.93 t/ha.

On the other hand, in Rangpur district, seeds were sown in 13 February and transplanted in 15 March, 2015 during the adaptive trials of Braus (Table 2). The seedlings age was 30 days. In Kurigram, seeds were sown on 24th February and transplanted on 21st March, 2015. The seedlings age was 25 days. Land preparation and transplantation was done with irrigation. Irrigation water was applied during the earlier and middle part of the growing season. Due to sufficient rainfall no irrigation was required during the later part of the growing season.

Table 2 also shows that, the mean growth duration of BRRI dhan28 and BRRI dhan48 in Rangpur was 109 and 113 days, respectively. Meanwhile this growth duration of BRRI dhan28 and BRRI dhan48 in Kurigram was 106 and 110 days, respectively. It indicates that in Braus season the growth duration of BRRI dhan28 and BRRI dha48 shorten a lot (around 35 and 31 days, respectively) compared to Boro season in Rangpur region (Table 1 &Table 2). Whereas the growth duration of BRRI dhan48 lengthen a little bit compared to Aus season. The average yields of BRRI dhan28 and BRRI dhan48 were 4.84 t/ha and 5.91 t/ha, respectively in different trials of Rangpur and those the yields were 4.38 t/ha and 5.70 t/ha, respectively in Kurigram. The mean yield of BRRI dhan28 and BRRI dhan48 in Rangpur region was 4.61 and 5.81 t/ha, respectively.

Table 3 demonstrates the number of irrigation, amount of irrigation water, rainfall received and total water use by the varieties. A total of 7 irrigations were applied in different farmer's plots. The amount of irrigation water applied in Rangpur and Kurigram varies from 401 mm and 394 mm, respectively for both varieties. Based on the date of harvest, varieties received 414-440 mm rainfall. It specifies that BRRI dhan28 and BRRI dhan48 receives more rainfall in Braus season than the Boro season (Table 1 & 3).The total water use for BRRI dhan28 and BRRI dhan48 were 815 and 825 mm, respectively in the Rangpur region. According to varietal trial of Braus, water productivity of BRRI dhan48 (0.71 Kg/m3) was found higher than BRRI dhan28 (0.57 Kg/m3). About 47% water can be saved by cultivating BRRI dhan48 as Braus if AWD method applied compared to conventional Boro rice cultivation. Furthermore, it is found that about 3.5 times more command areas can be increased if we cultivate Braus instead of Boro. Hence, transplanting date of Boro can be shifted to Braus about 30 days later from mid-February (Optimum transplanting date of Boro in northern region of Bangladesh) to mid-March which can reduce pressure on groundwater during dry season irrigation. Also Table 3 indicates that as a Braus variety the performance of BRRI dhan48 is much better than BRRI dhan28 and can produce more or less similar yield to Boro.

Conclusions

T. Aman-Rabi crops-Braus may be a unique cropping pattern in Rangpur region which is possible through early transplantation of BRRI dhan48 as Braus rice instead of Aus. As Braus rice, BRRI dhan48 gives a similar yield to Boro with almost 47% less water. It also increase water productivity. The seeds can be sown in mid-February. The seedlings at the age of 25-30 days are transplanted in mid-March after the potato harvest. Irrigation is required during the early and middle part of the growing season. But as naturally there would be sufficient rainfall, irrigation may be unnecessary during the latter part of the growing season. So, farmers can shift optimum transplanting date of Boro 30 days latter from mid-February to mid-March by cultivating BRRI dhan48 as Braus rice. Farmers can also increase 3.5 times more command areas by cultivating Braus instead of Boro. It also reduces the pressure on groundwater for irrigation as well as to ensure food security of the country.

Table 1: Water requirement, growth duration and yield performance of BRRI dhan28 in Boro season at Rangpur region during 2015

Location	Date of transplanting	Date of harvesting	Seedling age (days)	No. of Irrig	Amount of irrig. (mm)	Rainfall (mm)	Total water (mm)	Growth duration (days)	Yield (t/ha)
Rangpur	28.01.15	28.04.15	51	18	1338	148	1486	142	6.04
Kurigram	18.01.15	22.04.15	47	23	1452	160.4	1612	143	5.81
Av. In the Region			**49**	**21**	**1395**	**154.2**	**1549**	**143**	**5.93**

Table 2: Comparison between growth duration and yield performance of BRRI dhan28 and BRRI dhan48 (Braus) during 2015

Locations	Date of transplanting	Seedling age (days)	Date of harvesting		Growth duration (days)		Yield (t/ha)	
			BRRI dhan28	BRRI dhan48	BRRI dhan28	BRRI dhan48	BRRI dhan28	BRRI dhan48
Rangpur	15.03.15	30	06.06.15	11.06.15	109	113	4.84	5.91
Kurigram	21.03.15	25	11.06.15	14.06.15	106	110	4.38	5.70
Av. In the region					**108**	**112**	**4.61**	**5.81**

Table 3: Irrigation number, irrigation depth and water productivity of BRRI dhan28 and BRRI dhan48 (Braus) during 2015

Locations	Num. of irrigation		Amount of irrigation (mm)		Rainfall (mm)		Total water use (mm)		Yield (Kg/ha)		Water productivity (Kg/m^3)	
	BRRI dhan 28	BRRI dhan 48	BRRI dhan 28	BRRI dhan 48	BRRI dhan 28	BRRI dhan 48	BRRI dhan 28	BRRI dhan 48	BRRI dhan 28	BRRI dhan 48	BRRI dhan 28	BRRI dhan 48
Rangpur	7	7	401	401	414	414	815	815	4844	5914	0.60	0.73
Kurigram	7	7	394	394	420	440	814	834	4380	5702	0.54	0.68
Av. In the region			**398**	**398**	**417**	**427**	**815**	**825**	**4612**	**5808**	**0.57**	**0.71**

Polderisation in Bangladesh and Initiatives for Climate Resilient Polders under Changing Climate

Md. Nazibur Rahman, Executive Engineer, JRC, Bangladesh

Introduction

Polder is a low-lying tract of land enclosed by embankments (barriers) known as dykes that forms an independent hydrological entity which has no physical connection with outside water other than through manually operated devices (water control structures). Polderisation started in early 60s in Bangladesh as a follow up activities of the erstwhile Zaminder's (landlords) local initiatives taken up during pre-polderisation era. About 139 coastal polders are constructed in the coastal area of Bangladesh.

Historical background of Polderisation in Bangladesh

Before polderisation, much of the coastal area used to suffer from tidal flooding and salinity intrusion twice a day and the occasional cyclonic storm surges. Salinity problems were worst in the dry season. Most of the coastal area was a marshy and unproductive wetland. Population pressure was moderate and few human settlements were on high ground and local transportation was by country boats plying across flooded plains or along crocodile-infested coastal creeks. The seaward parts of the coastal zone supported extensive mangrove forests but very little in the way of agriculture. Winter crops and the first summer rice such as Rabi and Aus or Kharif 1 respectively were hardly grown because of the prevailing saline conditions, and the second summer rice such as Aman or Kharif 2 was dominant. Further inland where tidal effects were weaker, the picture gradually changed, but agricultural production was very low and uncertain (almost nil in some years) because of tidal flooding. During this period the coastal economy was dominated by fishermen, who traded fish for rice and other necessities. In order to increase food production, and make it more secure, local farmers under the leadership of landlords (Zaminder's) began to erect simple low-cost earthen dykes to protect the land from tidal flooding and salinity intrusion. This process was well established by 1900. The dykes or dwarf embankments remained fragile and were often damaged by high tides or cyclonic storms, so the people had to undertake considerable amounts of repair and rebuilding every year. Drainage was sometimes inadequate, so heavy rainfall or river floods often resulted in severe crop losses. Despite these limitations, agricultural production was much higher than in the previous situation, and enabled the coastal lands to support more and more people.

Following the abolition of the Zamindari system after 1954, this scenario of simple technology with local initiative and maintenance gradually ceased to operate. Increasing population and hence, need for land and food, led eventually to the initiation of the Coastal Embankment Project (CEP) in late 50s. Accordingly the CEP was designed and implemented with the aim of preventing tidal flooding and salinity intrusion in vast areas of low-lying land and thereby to increase the agricultural yields by rebuilding existing bunds and constructing new ones. This was perhaps the first large scale human intervention in the southwest coastal region of Bangladesh. About 139 coastal polders were constructed during 1960 to early 70s as mentioned earlier. The immediate socio-economic consequences were very impressive and positive. The construction of polder itself provided massive employment opportunities and stimulated local economies and trade. Transportation infrastructure was dramatically improved, integrating new roads with navigation facilities, which enabled products to be marketed over long distances. Outputs of crops in all seasons were higher than in any time before and much more secure. At this time better and more reliable control of water opened the door to other improvements in agricultural inputs and practices. Fishing remained significant, and the age-old tensions between fishermen and farmers persisted, but within acceptable tolerance. In all, a backward area of the region was transformed for the better incomes and living standards. New productive land was created by encouraging or accelerating the natural evolution of estuarine channels, sometimes by cross-dams.

This positive situation persisted for about two decades or so, but by the early 80s the secondary effects of polderisation in terms of sediment deposition began to be serious. Besides the construction of coastal polders, the drastic reduction of upstream flushing flow of the Ganges due to the commissioning of the Farakka Barrage during the dry season deteriorated the sedimentation problem in the region. The restricted drainage and consequent water-logging is now a major issue in many parts of the coastal zone. Lack of proper maintenance of infrastructures combined with the sediment deposition in the peripheral rivers of polders seems to be one of the major causes to create such problems. Due to the unnecessary interference of local community the smooth infrastructure operation began to break down and local people also damaged and modified infrastructures such as prying open structures and cutting embankments for their own local and short-term purposes and thus, the infrastructure did not meet their intended purposes. Some of this is related to the rise of shrimp culture, which was becoming more lucrative than agriculture in many places. The removal of protective forests and other vegetation left the embankments of polders vulnerable in many places. On the other hand, a series of severe cyclonic storms after 1970 coupled with the enormously increased population in this region made the situation even more complicated to survive.

Despite of the above facts, the Coastal Embankment Project was a great success, and in many ways remains so today. Lives and livelihoods here became more secure than any time before after implementation of Coastal Embankment Project.

Upgradation/Climate Resilience of Polders

The embankment systems of the polders were originally planned and designed to keep out of the highest tides, without any consideration of storm surges. The existing embankment system of polders has a level of protection of approximately 10 years return period only. Recent cyclonic storm damages and the anticipation of worse future situations on account of climate change, has caused this strategy to be revised. The embankments have to resist more than the maximum surge height. It is necessary to allow sufficient freeboard to resist wave overtopping. Additional problems have also been identified- the direct impact of sea level rise on salinity intrusion into the coastal zone as well as on polder drainage. Climate change is responsible for sea level rise and the occurrence of more intense cyclones. Monsoon rainfall is also predicted to increase as a result of climate change. Overtopping of embankments, salination of lands by flooding are some of these impacts. Saline intrusion is exacerbated by rising sea levels as well as reduction of upstream fresh water flows. Thus, coastal polders needs systemic restoration and upgrading to make it climate resilient to cope with the impact of climate change.

Objectives of Climate Resilient

- To increase the area protected in polders from tidal flooding and frequent storm surge, which are expected to worsen due to climate change;
- To improve agricultural production by reducing saline water intrusion within polders due to climate change-induced sea level rise and
- To ensure that the embankment would be protected against events of 25 years return period under change climate.

Initiatives for upgrading of embankment of Coastal polders

Under the stark realities of changing climate, Coastal polder needs to be upgraded to withstand impact of cyclonic storm surge, tidal flooding, and salinity intrusion due to Climate Change. As such, a project entitled "Coastal Embankment Improvement Project Phase-I (CEIP-I)" is being implemented by BWDB. Under this initiative the existing embankment system of the polders has been redesigned to cope with the impact of climate change. The designed parameters have been finalized based on the results of the state-of-the-art Mathematical Modelling.

Factors considered for upgrading/redesign of embankment

Considering the results of the storm surge analysis and the poject life, 25 years return period has been selected to determine the crest level of embankment. The following factors has been considered in the analysis.

- Simulated naturally occurred 19 severe cyclones at original tidal phase with and without climate change impact;
- All 19 cyclones were simulated opposite tidal condition with and without climate change impact;
- 25 year return period surge level considering exponential distribution function and climate change impact;
- Simulated wave model for 19 severe cyclonic wind considering climate change;
- 25 year return period significant wave height considering Weibull distribution;
- Wave run-up and freeboard allowing 5 l/s/m overtopping and
- 30 cm land subsidence and climate change impact.

The selection of crest level of embankments has been finalized based on the outcomes of the following modelling exercises:

- 25 years return period storm surge level;
- Alternatives for freeboard depending on overtopping limit of 5 l/s/m for several possible embankment slopes and roughness;
- 25 year return period monsoon level;
- 25 year return period monsoon freeboard and
- Allowance for subsidence.

Typical Design Section of new Embnkment of Polder

A sample case of Polder 35/1 is explained here for demonstraion. The computation of crest level of embankment is shown in Table 1. The table shows how the crest levels were computed for three locations (31, 32 and 33) on the eastern embankment of polder 35/1. The normal river-facing slope of an intertnal dyke is 1:3. However, because of the high wave action 1:5 slope has been considered for wave run up computation. The table shown here uses two possible river side slopes, with or without added roughness. Column A shows the original design crest level. The designer's selection of crest level, slope and slope roughness are shown in column S, T and U. Trchnical committees' approval is shown in column V. The revised designed section of the embankment is shown in Figure 1.

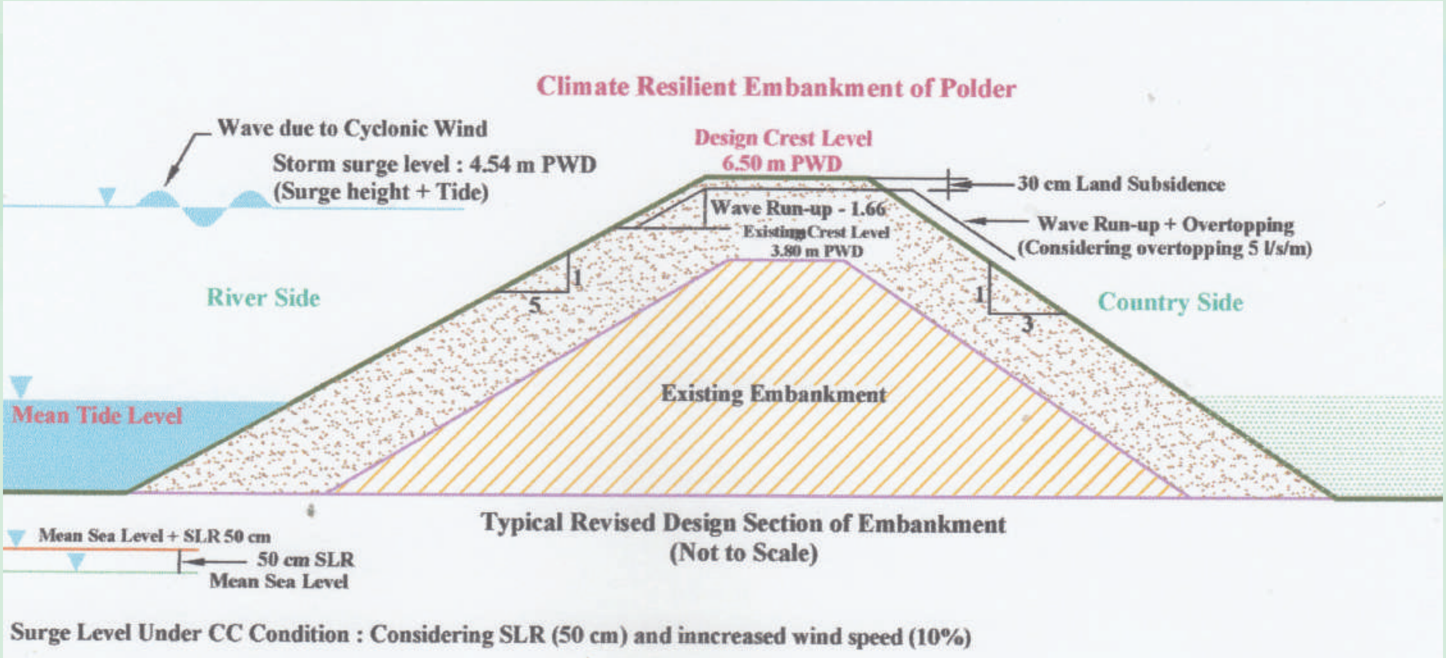

Figure 1: Typical Section of Embankment of Climate Resilient Coastal Polder

Table1: Computation of Crest Level of polder along Baleswar River

Points	**Location**	Previous Crest Level (m PWD)	Existing Avg. Crest Level (m PWD)	Modelled Storm Surge Level (m PWD)	Standard Deviation, std (m)	For comparison: Sidr Simulated	For comparison: Aila Simulated	Wave computation: Recommended Slope	Wave computation: Free board for Grass or smooth paved roughness 1.0	Wave computation: Free board for slope roughness 0.80	Allowance for subsidence	Reqd crest level w/o roughness no std	Reqd crest level w/o roughness + std	Reqd crest level w roughness & no std	Reqd crest level w roughness + std	Monsoon Levels: 25 year maximum in June-Sept period	Monsoon Levels: Max wind wave height in June-Sept period	Monsoon Levels: Free board w/o roughness	Monsoon Levels: Reqd crest level w/o roughness with subsidence and free board	Selection by Design Team: **Crest Level**	Selection by Design Team: **Slope**	Selection by Design Team: **Roughness**	m PWD: **Crest level recommended by Technical Committee**
		A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V
31	Morelgonj, Fanguchhi River	4.88	3.80	3.50	0.22	4.07	3.18	1:3	1.92	1.34	0.30	5.72	5.94	5.14	5.36	3.50	0.57	0.50	4.30	6.00	1:3	1	6.00
32	Mathbaria, Baleswar River	4.88	3.80	3.62	0.27	4.16	3.17	1:3	2.40	1.92	0.30	6.32	6.59	5.84	6.11	3.48	0.79	0.80	4.58	1:3 slope not used			
33	Sharankhola, Baleswar River	4.88	3.80	4.19	0.35	4.75	3.22	1:3	3.60	2.88	0.30	8.09	8.44	7.37	7.72	3.47	1.01	1.20	4.97				
31	Morelgonj, Fanguchhi River	4.88	3.80	3.50	0.22	4.07	3.18	1:5	1.08	0.84	0.30	4.88	5.10	4.64	4.86	3.50	0.57	0.30	4.10	1:5 slope not used			
32	Mathbaria, Baleswar River	4.88	3.80	3.62	0.27	4.16	3.17	1:5	1.44	1.08	0.30	5.36	5.63	5.00	5.27	3.48	0.79	0.50	4.28	6.00	1:5	1	6.00
33	Sharankhola, Baleswar River	4.88	3.80	4.19	0.35	4.75	3.22	1:5	2.04	1.68	0.30	6.53	6.88	6.17	6.52	3.47	1.01	0.60	4.37	6.30	1:5	0.80	6.50

Reference

1. Main Report, 2012, Coastal Embankment Improvement Project, Phase-I

Managed aquifer recharge: A viable option to tackle the water crisis in the coming days

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Perspectives

Groundwater depletion is a worldwide problem now. To sustain the growth rate in agricultural and other sectors, withdrawal of groundwater is the main option (and in many cases, the only available option). To tackle the situation we must consider both demand- and supply-side management. Demand-side management may be limited to some extent due to increasing demand of ecosystem services by the human being. In supply-side management, managed groundwater recharge (or artificial recharge) may be a viable option, as the increase in surface water supply is practically limited in most regions of the world (by both quality and quantity).

Features and dimensions of managed groundwater recharge

Managed aquifer recharge (MAR) is defined as "intentional banking and treatment of waters in aquifers" (Dillon, 2005). The term MAR was introduced as an alternative to "artificial recharge", which has the connotation that the use of the water was in some way unnatural (Dillon, 2005). MAR includes a great diversity of technologies to store and treat water including aquifer storage and recovery (ASR), infiltration basins, salinity barriers, soil-aquifer treatment, and riverbank filtration. The water resources management benefits of MAR are compelling. However, the question arises as to why MAR has not yet been implemented to an even greater degree. The answer often lies in that decision makers, such as water utility managers, water management agency officials, and political leaders, have not been provided an equally compelling, sound economic case for investment in the technologies.

Water storage is only possible in "closed" or "semi-closed" aquifers, in which the water does not flow from the injection site into deeper, inaccessible aquifers (NNC, 2002). Aquifers can also be "confined" (underneath an impervious layer that does not allow water to seep in from the surface) or "unconfined". Deep injection methods are necessary for confined aquifers and in locations where there is little suitable land available for surface recharge, whereas surface recharge methods are especially suitable for "water table" aquifers just below the earth's surface.

Methods of managed groundwater recharge

MAR includes a wide variety of processes by which water is intentionally added into an aquifer or induced to flow into and through an aquifer for treatment purposes. MAR, as defined by Dillon (2005), includes two main end-member types of technologies: (1) methods that are used primarily to increase the volume of water stored in aquifers; and (2) methods that are used primarily for water or wastewater treatment. MAR systems with a water storage goal include ASR, aquifer recharge using wells and infiltration basins, and river channel modifications to enhanced aquifer recharge (e.g., check dams). The benefit of storage-type systems is the net increase in the volume of water stored in the aquifer. The increased storage results in an increase in the volume of water available for later beneficial use (abstraction benefits). Additional potential benefits result from the water being in place in the aquifer (in-situ benefits). In-situ benefits include reduced groundwater pumping costs, and avoidance of the need to replace or deepen production wells, restoration or maintenance of environmental (e.g., spring) flows, avoidance of land subsidence, and prevention of saline-water intrusion (NRC, 1997).

MAR systems with a storage goal are primarily constructed in hydrological and engineering settings where there are at least periodic shortages of water and times when excess water is available that could be used to recharge aquifers. MAR is used in arid and semiarid lands, for example, to capture surface water that is episodically available during uncommon rainfall events. MAR can also be employed in areas with humid climates (such as South Florida and parts of India, Bangladesh) where there is a pronounced seasonality in rainfall. The systems are usually installed either where excess water is available (e.g., in-channel and off-channel infiltration systems in ephemeral streams and ASR systems at water treatment facilities) or where the water is used.

Economic and environmental issues

MAR may not be economical in many cases (Maliva, 2014), specially when considered alternative use of the land used for MAR (i.e. opportunity cost of the land), and the long-term benefits from ecosystem services and degradation values are avoided.

The costs of MAR projects include both capital, operations and maintenance costs, and finance costs (Maliva, 2014). Capital costs are fixed, one-time expenses incurred during the design and construction of the MAR system. Capital costs include, but are not limited to:

- Land;
- Testing costs, feasibility analyses;
- Consulting services for the design, permitting, and supervision of the construction;

- Construction costs (e.g., roads, piping, instrumentation, controls, and pretreatment systems); and
- Regulatory testing requirements during construction and operational testing.

Operation and maintenance costs include the following:
- Labor (system operation, regulatory requirements, administration);
- Electricity;
- Consulting services;
- Regulatory testing requirements (e.g., water quality testing);
- Maintenance costs (e.g., parts replacement, well and basin rehabilitation);
- Pre-treatment costs (additional treatment prior to recharge);
- Post-treatment costs (e.g., chlorination); and
- Raw water costs.

If reused water from agriculture and purified waste-water are used for MAR, risk of health hazard and soil degradation hazard may exist (Missimer et al., 2012). MAR can have both positive and negative effects on groundwater quality. This depends on the water itself, the MAR technique being used, and the interactions between the recharged water and the aquifer materials (NRC, 2008). The three most common water sources for aquifer recharge vary in quality:

- **River water:** Usually high quality due to national surface water quality guidelines
- **Treated wastewater:** High quality from modern treatment plants
- **Stormwater:** Variable quality, especially in urban areas

Deep injection methods typically require more careful attention to water quality than surface recharge methods because the water is not naturally filtered by soil and rock above the aquifer (Casanova et al., 2016). Many projects therefore use stormwater for surface recharge only, or they treat the water before injecting it underground. Surface recharge methods can use lower-quality water because the natural filter of soil and rock removes pollutants from the water before it reaches the aquifer (Casanova et al., 2016), although not all types of pollutants can be removed in this way. Water quality risks are assessed and reduced using groundwater modeling and monitoring.

Key challenges and potentials

Potential risk in MAR is that the disruptions affecting the recharged aquifers might be transferred to humans or to the environment. Because of the specific local characteristics of each MAR site, there is no universal solution that can be recommended and any change in laws must take this into account. It seems, however, possible to break down artificial recharge installations into two groups based on the quality of recharge water. Water whose quality is similar to drinking water standards is better-suited to direct or indirect injection into the aquifer, whereas for water whose quality is degraded, preference should be given to infiltration methods that enhance additional natural treatment in the subsurface. In both cases, post-treatment, the intensity of which depends on the foreseen use of the pumped water, is necessary before distribution.

There are over 1200 managed aquifer recharge projects around the world. The 'International Groundwater Resources Assessment Center' provides a portal for global MAR information at https://www.un-igrac.org/ggis/mar-portal .

Concluding remarks

Recurrent water resources crises call for a better understanding of hydrological processes and improved technical and socioeconomic groundwater management. In many areas of the world, growing freshwater scarcity currently emphasizes the need to close the water cycle gap by reconciling water supply with demand both in quantity and quality terms. The demand for closed water systems is obvious in semiarid areas. MAR is one of the strategies that can be used for quantitative and qualitative water management and adaptation to climate change in the field of water resources.

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Recently Developed Irrigation and Water Management Technologies of BARI to Combat Climate Change Effects on Crop Water Management

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Background

Irrigation and Water Management (IWM) Division is one of the 16 research divisions of BARI. It is devoted to contribute in increasing the yield and production of agricultural crops through the promotion of irrigation and the improvement of water resources management for sustainable agriculture. By this time, this division has developed about 45 irrigation and water management technologies of which most of them are being used at the field level.

Research Areas of IWM Division

- Crop water requirement and irrigation scheduling
- Water conveyance, distribution and applications
- Groundwater and surface water quality assessment, utilization and management
- On-Farm water management
- Saline and Waste water management for crop production
- Hill irrigation management
- Micro irrigation, drip, sprinkler etc.
- Climate change resilience technology

Deficit Irrigation Technologies for Different Upland Crops

- In this technique, irrigation is applied to avoid water deficit at critical growth stages of crops or irrigation is avoid at growth stages that are not/less sensitive to water stress
- In this technique irrigation water is applied to crops at 70-80% of field capacity of soil where 20-25% of irrigation water is saved with almost no loss of yield
- This irrigation option is effective for drought and saline prone areas where irrigation water source is very limited

Sunflower and onion cultivation under deficit irrigation

Alternate Furrow Irrigation Technology for Row Crops

Salient Features

- Alternate furrow irrigation is a way of irrigation method for row crops cultivation technique that irrigation water supply in alternate furrows and keep in-between furrow dry.
- Dry furrows are irrigated in next irrigation event, while irrigated furrow remains dry
- About 35-40% water can be saved with almost no sacrifice in yield.
- This irrigation method is suitable for row crops like tomato, potato, maize, cabbage, cauliflower etc.
- This is a potential water saving technology in water scarcity areas

Alternate furrow irrigation for tomato and Potato

Cultivation of High Value Crops under Drip Irrigation (Fertigation)

Fertigation is a modern technique in which fertilizer is applied with water to the crops through drip system. It is very much effective for high value horticultural crops.

Salient Features

- Irrigation water saves 45-50%
- About 50-55% of Nitrogen and 35-40% of potash fertilizers can be saved
- About 20-30% of crop yield may be increased over traditional method
- BCR of this system varies from 1:4 -1:5



Cultivation of high value crops like, to mato, strawberry and capsicum, etc under fertigation system

Conjunctive Use of Saline and Fresh Water for Crop Cultivation in Saline Area

The cropping intensity in coastal areas is very less in compare to other areas of the country due to soil and water salinity. The fresh water availability is very scarce during dry season irrigation. But a huge amount of water resources of medium salinity is available in the steams and canals of the coastal zone.

- In this method, fresh water from ponds/ditches is applied at the initial growth stages of the crops and medium saline canal water (EC ranges from 4.5-6.8 dS/m) is used as irrigation at the mid and latter stages of the crops in coastal areas.
- Only 5-6% yield can be reduced by this system than fresh water irrigated crops.
- Medium saline cannel or water may be an alternate option for irrigation in saline prone areas.
- Additional crops can be grown using this option



Conjunctive use of saline and fresh water for mustard, wheat and mazie cultivation in saline area

Improved Techniques for Salinity Management

Drip irrigation on raised beds is one of the improved techniques for soil salinity management for crop production in coastal areas.

Salient Features

- Using drip irrigation or manual pump irrigation methods on raised bed with mulch, farmers in the saline areas can grow high value horticultural crops like as tomato, chili, watermelon, cucumber etc.
- It can reduce soil salinity substantially 10 dS/m to 4.5 dS/m.




Cultivation of horticultural crops in raised bed under drip irrigation in saline areas

Sprinkler Irrigation Technology for Onion and Garlic Cultivation

Salient Features

- Irrigation water is applied to the crops through sprinklers by pumping from underground and surface water sources
- It is suitable for shallow rooted crops in light soils. It is also effective for leveled as well as undulated fields.
- Irrigation is applied to onion at 7-8 days interval and 10-11 days interval for garlic through this system.
- At least 20-25% of irrigation water can be saved over the traditional method.
- Infestation of trips to onion and garlic can be reduced.
- The BCR of this system was found for onion is 1:3 and 1:2 for garlic.

Cultivation of onion and garlic through sprinkler irrigation system

Irrigation Technology for Crop Production with Domestic Wastewater

Domestic wastewater can be used as irrigation water for cultivation of potato, wheat, maize, vegetable crops etc. in peri-urban areas of dry prone regions where the availability of irrigation water is very less from surface/ground sources. Most of the cases, the domestic wastewater is rich in nutrients.

Salient features

- About 20-25% major fertilizer (NPK) can be saved using this irrigation water.
- The produce is safe from any health hazard.
- It can be used as an alternate source of irrigation water in dry prone areas.
- It is possible to increase additional crops using the technology in drought prone area.

Wastewater irrigation to wheat, potato, maize and vegetables crops

Cropping System Intensification in the Salt-Affected Coastal Zones of Bangladesh

The coastal areas of Bangladesh are affected by varying degrees of salinity and the cropping intensity is comparatively lower than any other parts of the country. The cropping patterns followed in the coastal areas are mainly fallow-fallow-transplanted aman. Irrigation and Water Management Division along with Agronomy and On-farm Research Divisions of BARI is implementing a project "Cropping Systems Intensification in the Salt Affected Coastal Zones of Bangladesh and West Bengal, India" funded by ACIAR/ KGF in Dacope, Khulna and Amtali, Barguna during 2016-2019. Cropping Systems Intensification in the Salt Affected Coastal Zones of Bangladesh aims to sustainably increase cropping intensity and productivity in the coastal zones of Bangladesh particularly in the dry (Rabi) season through integrated soil, water and crop management. The technique of drip fertigation and conjunctive use of fresh water at early crop growth stages and saline water at later growth stages of sunflower and maize crop in coastal areas of Bangladesh could be an alternative irrigation method for increasing crop yield and water productivity with a little reduction in crop yield compared to fresh water irrigation during rabi season in the salt affected areas of Bangladesh. During dry season, the non -rice crops, like tomato, watermelon , mustard, wheat, maize ,sunflower, grass pea are being tried in fallow lands after T.Aman harvest to increase the cropping intensity as well as to increase the family income of the farming community

Photographic view of maize and sunflower at different growth stages under the conjunctive use of fresh and saline waterat coastal region of Bangladesh

Drought tolerance of Aus rice genotypes and irrigation water savings

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Objective: The objective of the present study was to examine the drought tolerant level, and observe the water savings under different irrigation levels on several Aus rice mutants and cultivars.

Materials and Methods

Field study (Rajshahi):

The irrigation treatments (main-plot) were: T1 = Control (3 days Alternate Wetting and Drying, AWD); T2= normal levee (farmer's practice, 10~12 cm) and supplemental irrigation (throughout the growing season) when plant available soil-moisture (PASM) drops below 50% ; T3 = 20 cm height levee around the plot, and rainfed; T4 = 20 cm height levee around the plot, and supplemental irrigation during booting to soft-dough, if PASM drops below 50%, T5 = 20 cm height levee around the plot, and supplemental irrigation during booting to soft-dough, if PASM drops below 75%. The varieties (sub-plots) were: V1 = N4/350/P-4(5), V2 = N10/350/P-5-4, V3= NERICA-4 (N4/250/P-2(6)-26 for control study), V4= Binadhan-17, V5 = BRRI dhan48 (check)

Control study (In rain-shelter, Mymensingh):
The treatments were: T1 = Control (normal irrigation, 3 days AWD); T2 = Irrigation when plant available soil-moisture (PASM) drops below 60% (throughout the growing season); T3= Irrigation during booting to soft-dough stage, if PASM drops below 60% and normal irrigation for the rest period; T4= Irrigation when PASM drops below 75% (throughout the growing season). T5 = Irrigation when PASM drops below 85% (prior to booting stage), and from booting to soft-dough stage at 75% PASM.

Results
Normal irrigation (4 nos.), rainfed (only 01 life irrigation) and soil moisture basis irrigation (50 and 75% depletion of PASM – 02 and 01 frequency, respectively) (Table 1.2) showed insignificant yield difference, indicating that the cultivars had the capability to produce good yield under water stress condition.

Under both field and control study, mutant N4-4(5), Binadhan-17, and BRRIdhan48 produced good yield indicating their tolerance capacity under drought (12 – 18 days).

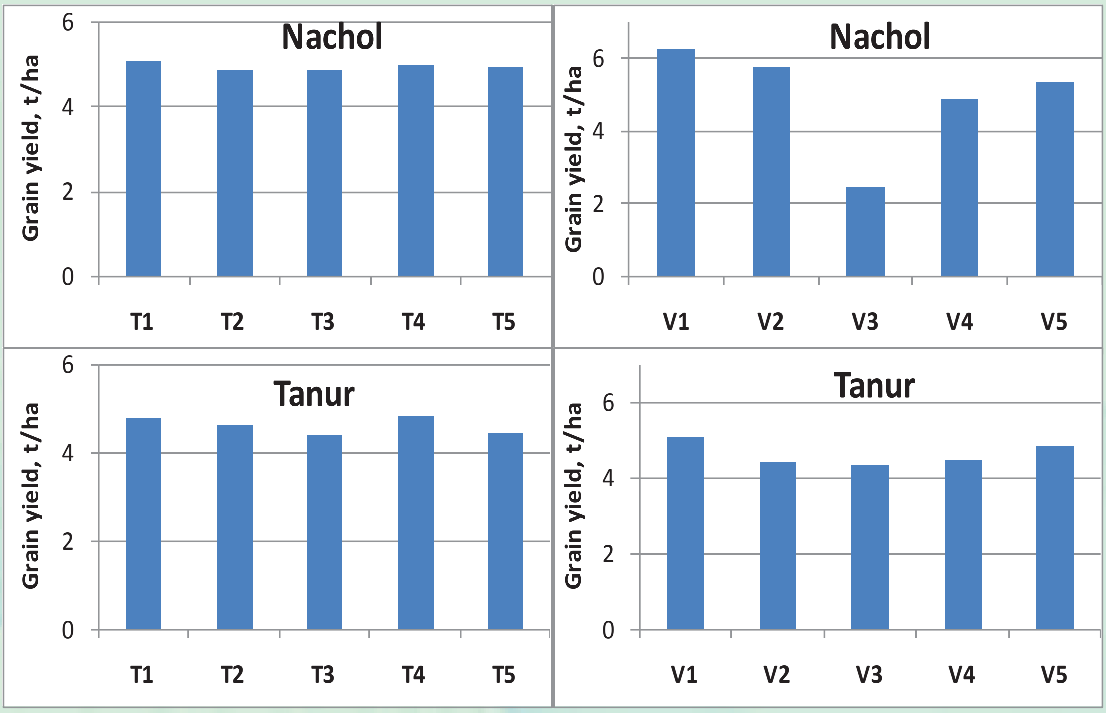

Fig.1. Grain yield under different irrigation regimes and cultivars

Table 1. Irrigation amount and water savings under different treatments (Field study- Nachol, Rajshahi)

ID	Common irriga., (cm)	Additional Irri. Nos.	IW (cm)	TIW (cm)	Water savings (%)
T1	25	4	19	44	-
T2	25	2	8	33	25
T3	25	1- life irrigation	2	27	39
T4	25	2	7	32	27
T5	25	1	4	29	34

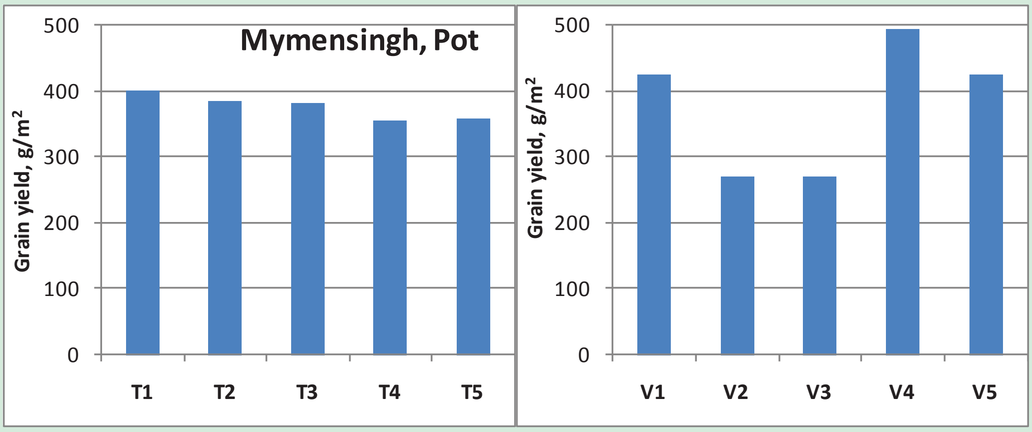

Fig.2. Grain yield under different irrigation regimes and cultivars

Table 2. Irrigation amount and water savings under different treatments (Pot culture, 1.5 m 1.0 m 0.28 m)

Irrigation treatment	Common irriga. (cm)	Additional Irri. Nos.	Total irrigation (cm)	Water savings (%)
T1	16	06	44	-
T2	16	04	35	20
T3	16	04	34	23
T4	16	03	29	34
T5	16	03	30	32

Conclusion

It is revealed from the results that, one or two irrigations are sufficient to achieve good yield for the above three cultivars, which would save substantial amount of irrigation water (25-39%).

Estimation of groundwater recharge from rainfall in Mymensingh region

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Objective

The objective of the study was to estimate the yearly recharge under field condition at North-eastern region, Mymensingh District of Bangladesh.

Introduction

Groundwater is the main source of water supply to both urban and rural populations as well as to industry and agriculture. Among various water cycle characteristics, groundwater recharge is the leading hydrologic parameter determining groundwater resources availability and sustainability. Sustainable use of groundwater must ensure not only that the future resource is not threatened by overuse and depletion, but also those natural environments that depend on the resource (Ali 2016, Abo and Merkel 2014). Accurate estimation of groundwater recharge is extremely important for proper development and management of the resource. The objective of the study was to quantify the yearly recharge under field condition using Tracer technique. The recharge was also estimated following Water Balance approach, and compared with tracer technique.

Materials and Methods

The present study was conducted during 2014, 2015 and 2016, at the experimental field of Bangladesh Institute of Nuclear Agriculture, Mymensingh (the soil is silt loam, and the sub-surface strata is of alluvial deposit). The tracer injection area (1.2 m × 1.2 m) was separated from the surrounding soil by polythene sheet up to 0.60 m to ensure the flow of water downward. Chloride tracer was applied as a pulse at 15cm depth within the soil profile at the initiation of rainy season. Infiltration of precipitation transports the tracer downward (Piston flow model). The subsurface distribution of applied tracer was determined at the end of rainy season by digging a trench for sampling. The vertical distribution of the tracer was used to estimate the velocity, and the recharge rate was calculated following standard procedure (Chand et al. 2005, Scanlon et al. 2002).

In case of Water Balance approach, a simplified form of water balance equation (Yin et al., 2011) was used to estimate the recharge, neglecting the change in soil moisture (year to year). The surface runoff was estimated using a modified form of USDA-SCS method (subtracting the 'actual evapotranspiration (ETa)' from Rainfall). Daily reference crop evapotranspiration (ET0) was calculated using 'ET0 Calculator' software of FAO. The ETa was calculated considering soil moisture stress factor (or, dryness factor).

The response of water-table (data taken in nearby observation well, 15 days interval) due to rainfall was monitored. The yearly fluctuation was about 5.5 m. It is to be mentioned here that the associated aquifer is not an unconfined/water-table aquifer, but semi-confined / leaky aquifer.

Results and Discussions

The vertical distribution of the tracer concentration is depicted in Fig.1. The recharge rate found using tracer and water balance method for the year 2014, 2015 and 2016 are summarized in Table 1. From the tracer technique, the average recharge rate for the year 2014, 2015 and 2016 was found as 196 mm, 257 mm and 233mm, which were about 10.2%, 12.4 % and 11% of the yearly rainfall, respectively. From the Water balance method, the average recharge rate for the year 2014, 2015, and 2016 was found as 139 mm, 156 mm and 130mm, which were about 7.3%, 7.5 % and 6.7% of yearly rainfall, respectively.

The calculated recharge rates in tracer technique represent the time between application and sampling, which covers recharge period of the year (which is also true for Water Balance method). Sukhija et al. (1996) reported in a review that in the alluvial tracts of Uttar Pradesh, Punjab and Haryana of India, recharge rates were found 120-200 mm (12-20% of rainfall) by tracer technique. The varying values of recharge from natural rainfall reflect differences in the various factors that affect recharge, including the thickness and hydraulic properties of the underlying unsaturated regolith, the pattern of rainfall, and environmental conditions such as evapotranspiration. In our study, the recharge rate in tracer technique is higher than that of Water Balance method. Water Balance approach is an indirect approach in which the recharge rate depends on the accurate estimation of other components. Hence, tracer technique can be regarded more reliable than the Water Balance method. Overall, the rate found in this study (average 228.7 mm/yr) can be regarded as a guide in sustainable groundwater withdrawal in the area.

Table 1. Recharge rates under different methods and years

Year	Recharge amount by	
	Tracer method	Water balance method
2014	196 mm (10.2 % of rainfall)	139 mm (7.3% of rainfall)
2015	257 mm (12.4% of rainfall)	155.5 mm (7.5% of rainfall)
2016	233 mm (11 % of rainfall)	130 mm (6.7 % of rainfall)

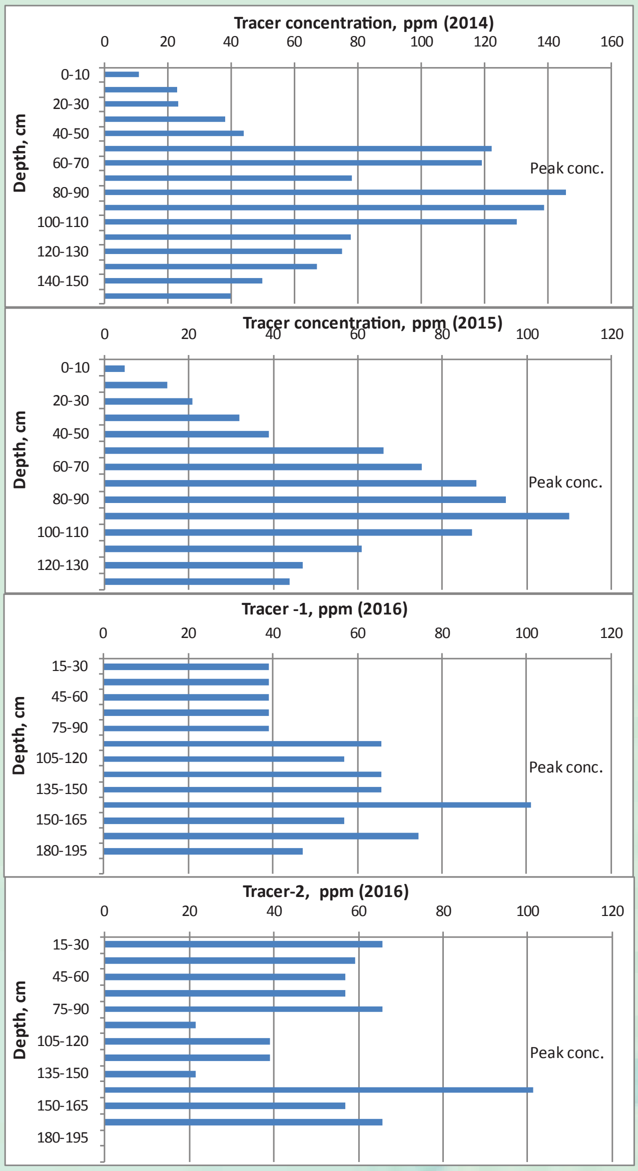

Fig.1. Concentration profile of chloride in different years

Conclusion

Recharge is a major component of the groundwater system. Quantitative determination of the rate of natural groundwater recharge is a pre-requisite for efficient groundwater resource management. The three years average of recharge rate at Mymensingh location was found as 228.7 mm/year under tracer technique; and 141.7 mm under water balance method.

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Morphological Changes of River Teesta during the Last Decade

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Introduction

Bangladesh, the second largest deltaic flood plain of the world, is mostly formed with huge sediment deposition by numerous tributaries and distributaries of the three great river systems- Ganges-Padma, the Brahmaputra-Jamuna and Meghna. There is a complex network of 405 rivers in the country including 57 transboundary rivers. Most of the water resources of Bangladesh are received from upstream countries through these transboundary rivers. Annually 1000 billion cubic meter (cumec) of flow drain to Bay of Bengal through Lower Meghna and about 1.10 billion tons of sediment enters into Bangladesh. However, we have little influence over these transboundary rivers. River Teesta, one of the major transboundary rivers is the biggest fresh water resource in the northern region flowing through the 5 districts- Rangpur, Lalmonirhat, Nilphamari, Kurigram and Gaibandha. To facilitate supplementary irrigation during monsoon season, Bangladesh Water Development Board (BWDB) constructed Teesta Barrage in 1988. Since then, this river is playing a vital role for boosting agriculture production in northern region and enhancing self-reliance in food stock of Bangladesh.

In recent years, Teesta is facing challenges of very low flow (8 cumec) during dry season and abnormal erosion-deposition phenomena in certain places of its course. To meet agricultural water demand and provide supplementary irrigation during dry season, India also constructed a barrage in ‘Gagoldoba’ just few kilometers upstream of Bangladesh border. In absence of water sharing treaty with India for river Teesta, India is withdrawing excess water for irrigation during dry season without keeping minimum water for downstream channel sustainability and releasing excess water to downstream Bangladesh during monsoon experiences flooding which causes enormous sufferings of public and properties living alone the banks of river Teesta. This difference of highest and lowest flow makes the river susceptible to meet demand of irrigation, aquaculture and pose a great threat to river management.This study is undertaken to get an enhanced perceptive of the morphological response of river Teesta by observing shifting of bank line and estimating erosion deposition volumes over a period of years. This study will assist in improved understanding of the morphological changes of the river and help in formulating river management planning.

Hydrology of River Teesta

River Teesta, a much controversial transboundary river,has originated from the Himalayas Range of Sikimin India and enters through Dimlaupazila under Nilphamari district and falls into river Brahmaputra-Jamuna in Sundarganj upazila under Gaibandha district. Physical descriptions of the river and location of the bathymetric survey sections are listed in Table 1.

Table 1: Physical descriptions and bank location of bathymetric survey sections of river Teesta as per Rivers of Bangladesh (BWDB), 2011.

Length	129 km.	
Width	0.7km (minimum), 5.5km (maximum), 3km (average)	
Bank Level (upstream to downstream)	Left : 57.10m to 18.37m	
	Right : 56.18m to 19.00m	
Bed Level (upstream to downstream)	54.00m to 16.74m	
CS station number	Left Bank (upazila, district)	Right Bank (upazila, district)
RMT1	Chilamri, Kurigram	Sundarganj, Gaibandha
RMT2 to 5	Ulipur, Kurigram	Sundarganj, Gaibandha
RMT6	Rajarhat, Kurigram	Pirgacha ,Rangpur
RMT7	Rajarhat, Kurigram	Kaunia, Rangpur
RMT8 to 10	Lalmonirhat, Lalmonirhat	Kaunia, Rangpur
RMT11to 12	Aaditmari, Lalmonirhat	Gangachara,Rangpur
RMT13 to 14	Kaliganj, Lalmonirhat	Gangachara,Rangpur
RMT15	Kaliganj, Lalmonirhat	Jaldhaka, Nilphamari
RMT16	Hatibandha, Lalmonirhat	Jaldhaka, Nilphamari
RMT17 to 20	Hatibandha, Lalmonirhat	Dimla, Nilphamari

Teesta is a braided, perennial and non-tidal river with low flow during February to April (8cumec) and higher flow during July to September (4494cumec). From Table 1, it is observed that the elevation of bed level have been reduced about 37.26m from near off take with a travel length of 129km to outfall. Due to this higher gradient, this river is flashy in nature.

River Morphology and Research Circle (RMRC) of Bangladesh Water Development Board (BWDB) is mandated for monitoring river morphology and investigation of bathymetric survey of 170 rivers including Teesta. River Morphology Processing Branch (RMPB) under Processing and Flood Forecasting Circle (PFFC) of Bangladesh Water Development Board (BWDB) is responsible for collection, storage, processing and analysis of morphological data collected from field divisions of RMRC. River Teesta is divided into 20 sections along its length for morphological investigations and is surveyed once in every 2 years at an interval of around 6km.The flow path and bathymetric survey station locations of river Teesta are illustrated in Figure 1.

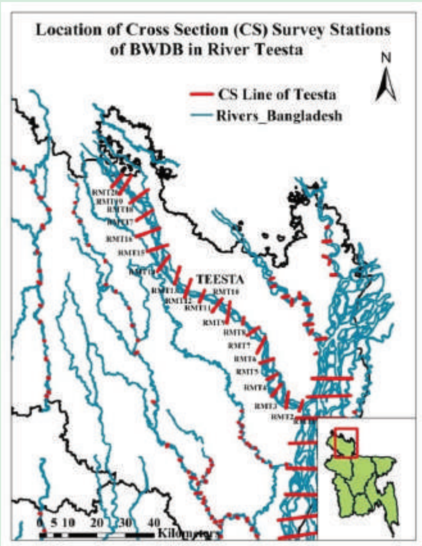


Figure 1: Flow path and bathymetric survey station locations of river Teesta.

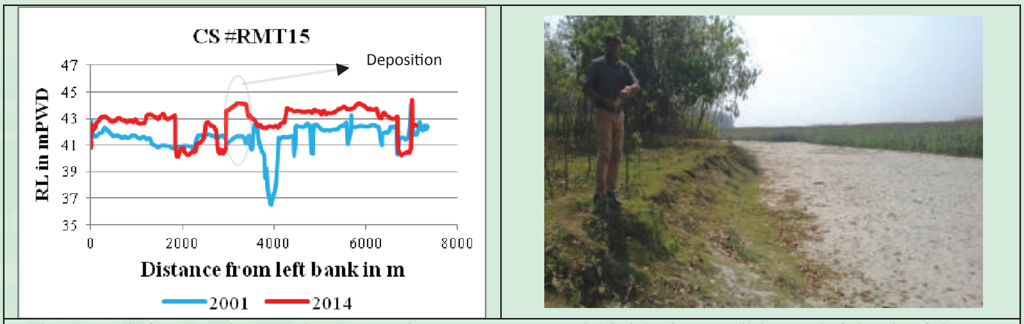


Figure 2: (left) Superimposed cross section at RMT 15 and (right) site condition at left bank of the CS (Daoabari union, Hatibandha upazila) of river Teesta.

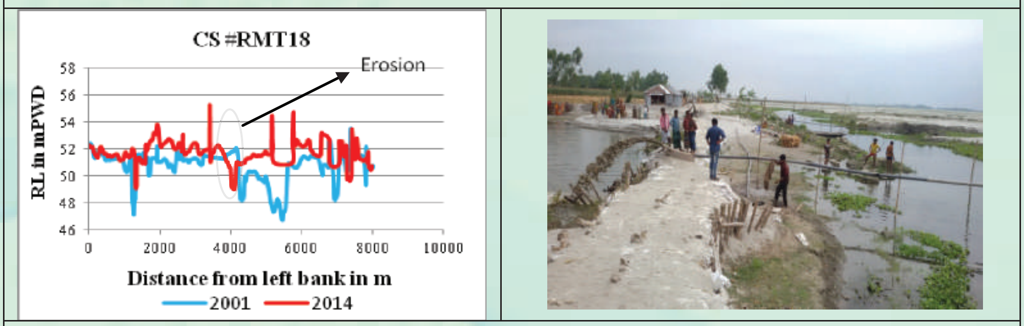


Figure 3: (left) Superimposed cross section at RMT 18 and (right) site condition at left bank of the CS (Guddimari union, Hatibandha upazila)of river Teesta.

Methodology

Cross sectional data of river Teesta during period of 2001 and 2014 are taken into consideration for morphological analysis and superimposed. From superimposed cross-sections of the 2 different years, erosion or deposition phenomena of the river are easily understandable. Erosion and deposition volumes are estimated by calculating average area (erosion/ deposition) generated between 2 superimposed sections of year 2001 and 2014, multiplied by the distance between the 2 sections (Table 2).

Table 2: Estimated erosion and deposition volume of River Teesta.

CS station	Location (km)	Erosion area (m^2)	Deposition area (m^2)	Remarks	Total erosion/ deposition volume between two sections(m^3)
RMT1	3	2209.84	267.42	Erosion dominated (1942.42)	-
RMT2	9.5	120.81	2927.27	Deposition dominated (2806.46)	2808117.65
RMT3	16	1319.51	1732.79	Deposition dominated (413.29)	10464174.83
RMT4	22.5	868.55	2264.73	Deposition dominated (1396.19)	5880800.58
RMT5	29	1864.40	2865.34	Deposition dominated (1000.94)	7790666.65
RMT6	35.5	553.84	3052.10	Deposition dominated (2498.25)	11372375.30
RMT7	42	1089.91	2295.28	Deposition dominated (1205.37)	12036766.30
RMT8	48.5	401.12	1833.33	Deposition dominated (1432.22)	8572152.88
RMT9	55	169.27	1833.15	Deposition dominated (1663.88)	10062304.85
CS station	Location (km)	Erosion area (m^2)	Deposition area (m^2)	Remarks	Total erosion/ deposition volume between two sections(m^3)
RMT10	61.5	763.91	3014.52	Deposition dominated (2250.61)	12722066.18
RMT11	68	180.06	2198.35	Deposition dominated (2018.30)	13873930.20
RMT12	74.5	554.26	2945.14	Deposition dominated (2390.88)	14329827.20
RMT13	81	1101.43	1072.16	Erosion dominated (29.27)	7675246.80
RMT14	87.5	3632.10	2892.19	Erosion dominated (739.91)	2499810.63
RMT15	94	817.81	1779.62	Deposition dominated (961.80)	721159.40
RMT16	100.5	294.96	4300.79	Deposition dominated (4005.84)	16144821.55
RMT17	107	1338.82	868.77	Erosion dominated (470.05)	11491312.95
RMT18	114	518.76	3235.41	Deposition dominated (2716.65)	7863122.75
RMT19	121	1337.95	654.44	Erosion dominated (683.51)	7116018.70
RMT20	127	1960.53	1718.96	Erosion dominated (241.57)	1387616.40

Figure 2 shows deposition at left bank of RMT 15 and figure 3 shows bank erosion at left bank of RMT 18.
Both conditions agree with field scenario as seen in the photographs taken respective sights.

Results and Discussion:

The estimated net erosion/deposition areas and volumes during the time period of 2001 to 2014 for all twenty cross sections of river Teesta are represented in Figure 4. It has been found that river Teesta has eroded significantly during 2001 to 2014 at several locations near its off take (cross section number RMT1, RMT13,RMT14, RMT17,RMT19and RMT20) (Figure 4, left). Erosion dominates between cross section number RMT 13&14 (2499810.63m3). Erosion near sections RMT 19&20 (near Hatibandha and Dimla upazila has also been found to be 1387616.40m3). The highest net erosion area (1942.42m2) has been found at the outfall the river (RMT1 near Chilamri and Sundarganj upazila). On the other hand, deposition is found in most of the upstream sections with very low flow. The highest deposition area is fond at cross section number RMT16 (4005.84m2). The highest net deposition volume has been found to be 16144821.55m3 between sections RMT 15 &16 near Kaliganj, Hatibandha and Jaldhaka upazila

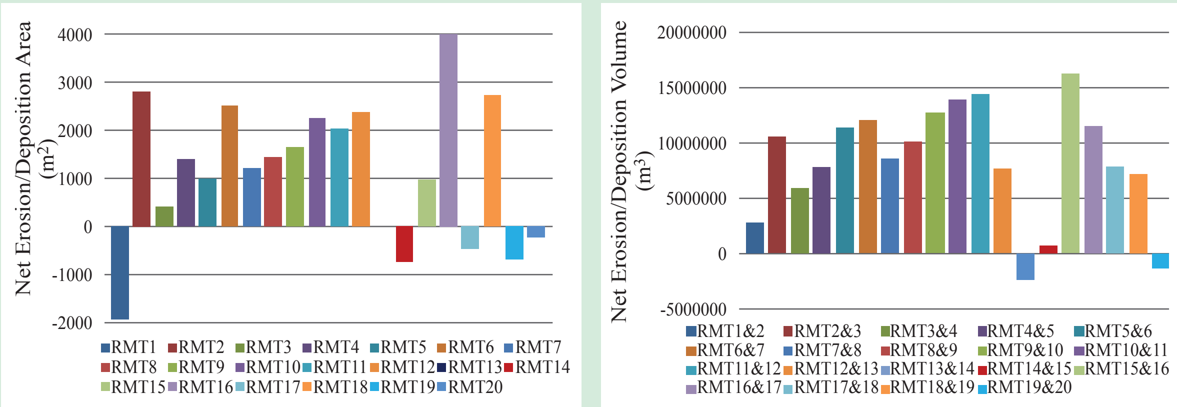


Figure 4: (left) Summary of cross-section wise erosion and deposition area of river Teesta.(right) Summary of erosion and deposition volume between the cross-sections of river Teesta

Conclusion and Recommendation:

This study has tried to clearly indicate the location of significant erosion/ deposition alone the entire length of river Teesta. Erosion was mainly observed near off take (Hatibandha of Lalmonirhat and Dimla of Nilphamari) and near outfall (Chilmari of Kurigram and Sundargonj of Gaibandha) portion. Other places alone the river, sedimentation/ deposition phenomena were predominant with highest deposition observed in Kaligonj of Lalmonirhat and Jaldhaka of Nilphamari.River management through river improvement is one of the prior agenda of Bangladesh government. River improvement through capital dredging program is an ongoing mega project of government implemented by BWDB, BIWTA. This study will help to find appropriate locations of river dredging works for Teesta. In addition, very low flow in dry season and high flow during monsoon season are also responsible for change in river morphology. Joint River Commission (JRC) of Bangladesh can continue their negotiation with India to establish a water sharing treaty so that channels can be operative with minimum standard flow all the year and meet agriculture and aquatic demand in the northern region.

Nature-based Solutions for Water Management under Climate Change

Fazlur Rashid, Superintending Engineer/Director, Planning-1, BWDB, Dhaka

Introduction

Climate change is already affecting and will increasingly affect natural resources, especially water resources and aquatic ecosystems. In this context, there is a growing interest for a range of solutions inspired by nature, under different terminologies: generic terms like eco-engineering, support for ecosystem services or green infrastructure, specific examples of these like ecological rehabilitation, Sustainable Drainage Systems (SuDS) or Natural Water Retention Measures (NWRM), etc.

Nature-based Solutions

Nature-based Solutions are defined as “actions to protect, sustainably manage, and restore natural or modified ecosystems”. Nature based Solutions have multiple benefits and do not respond to a single objective. They can simultaneously increase the resilience of the territories to climate risks (hurricanes, droughts, floods, erosions, marine submersion...), play a role in biodiversity and soils protection and ecological rehabilitation and meet other development challenges such as access to safe drinking water, food security and human health, land degradation neutrality, sustainable cities as well as tourism. By doing so, they also contribute to enhance project ownership by citizens. Moreover, the multiple benefits of Nature-based Solutions contribute to the reduction of the costs of action.
We can list some nature based solutions in agriculture water management practices. These are:

Sl. No.	Name	Sl. No.	Name
1	Low till agriculture	7	Intercropping
2	No till agriculture	8	Floodplain restoration and management
3	Strip cropping along contours	9	Infiltration basins
4	Restoration of natural infiltration to groundwater	10	Rain gardens
5	Controlled traffic farming	11	Rainwater harvesting
6	Targeted planting for "catching" precipitation	12	Wetland restoration and management

Nature Based Agriculture

Other than nature based solutions in agriculture water management, we should pay attention to promote nature based water resources planning and management for urban planning, disaster prevention, drainage improvement, maintain natural course of water bodies etc. As for example:

Climate resilient urban planning

Urban development leads to changes of surface cover that disrupt the hydrological cycle in cities. In particular, impermeable surfaces and the removal of vegetation reduce the ability to intercept, store and infiltrate rainwater. Consequently, the volume of storm water runoff and the risk of local flooding rise. This is further amplified by the anticipated effects of climate change leading to an increased frequency and intensity of heavy rain events. Hence, urban adaptation strategies are required to mitigate those impacts.

A nature-based solution is urban green infrastructure as it contributes to the resilience of urban ecosystems by providing services to maintain or restore hydrological functions.

Urban green infrastructure as nature-based solution to regulate surface runoff becomes increasingly important, as climate change and urbanization alter the urban water balance.

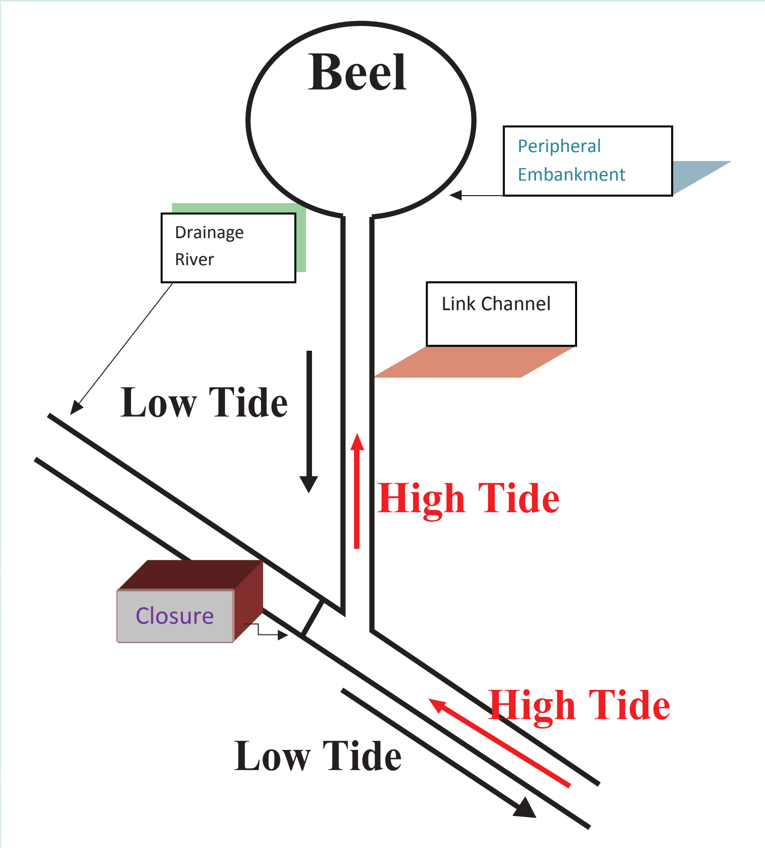
Natural water retention measures in catchment for flood management

Natural water-retention measures could play an important role in managing floods. These nature-based solutions store rainfall and allow it to evaporate back into the atmosphere to help prevent water flowing into urban areas, where it can cause the greatest damage. As well as reducing flood risk, they can have value for biodiversity, recreation and water quality because they reduce soil erosion and can prevent agricultural pollution running into rivers.

Tidal River Management (TRM) for nourishing natural drainage

TRM has emerged as an indigenous process to tackle the climate change and water logging issues. TRM allows the natural siltation system to elevate the land by 1-3 meters within 3-5 years time.

TRM is sufficient in controlling the tides and carrying sediments and silt to raise the level of low-lying lands and reclaim them for agricultural use.



TRM allows: a) Natural movement of tide into a Beel b) Tidal Basin stores water during high tide and release during low tide c) Siltation takes place into the basin during high tide d) During low tide clear water erode the river bed and increase the drainage capacity.

Conclusion

Compared to technology-based solutions to climate challenges, nature-based solutions are often lower cost, longer lasting, and have multiple synergistic benefits for a variety of sectors and political goals. Nature-based approached can produce important additional socio-economic benefits for the environment, citizens, and the local economy.

The potential power of nature and the solutions it can provide to global challenges in fields such as climate change, food security, social and economic development. So, to realize their full potential, nature based solutions must be developed by including the experience of all relevant stakeholders such that 'solutions' contribute to achieving all dimensions of sustainability.

Empowering Young Women through Rainwater Harvesting for Homestead Eco Farming and Generate Entrepreneurship

MuktaAkter
Executive Secretary
Bangladesh Water Partnership

Introduction

Bangladesh is one of the most climate vulnerable countries in the world and within the country the coastal area consisting of about 30% of the total area of 147,570 sqkm. Nearly one third of the 160 million people of the country live in this area. Due to salinity water for drinking, agricultural and industry is becoming increasingly unavailable and with the Climate change impact including sea level rise further increase of salinity. Due to scarcity of safe water many people are drinking contaminated water and suffering from water borne diseases. People in the area are not even able to practice homestead vegetable gardening, which can provide basic needs for their livelihoods. Young women are often tasked to collect drinking water, often walking 4-5 km to reach safe water source. Heavy workload affects these women's education with rates of school dropouts, limiting their future opportunities.

Rainwater harvesting and its use for drinking as well as agricultural purposes appear to be an attractive option to overcome their challenges. On the average, the coastal area receives about 2500 mm rain water every year and it is the only source of fresh water in coastal area. Installation of rain water harvesting (RWH) system allows young women to free their time from labour work, providing opportunities for them to spend time to study. Using harvested rainwater in vegetable gardening creates 'window' to earn additional income for the family. Such scheme could be also set up through micro finance institutions. If successful, such system is expected to protect the dignity and honour of the young women living in these remote areas from physical abuse and school dropouts.

Through Bangladesh Water Partnership, a partner country of Global Water Partnership (GWP), a small pilot project involving 6 young women with 6 Rainwater Harvesting Systems for drinking water supply and homestead green farming have been installed in a coastal village called 'Bijoypur' 2017. Initial results both in terms of rainwater harvesting and its multiple use (drinking, agriculture, fisheries etc.) appears to be very encouraging. The community people of the pilot village now have high interest in the RWH system and homestead green gardening.

Based on the above a larger pilot study covering more districts of the costal belt will be conducted to validate the initial findings of the limited pilot mentioned above.

Objectives

- Support young women of coastal Bangladesh gain easy access to clean water for drinking and commercial vegetable cultivation.
- Free young women from labor of collecting water and reduce school dropouts.
- Increase young women's family income to convince parents to support them to continue schooling.
- Empower young women to participate in decision-making within family and community.
- Build awareness and provide knowledge on climate change/sea level rise and its adverse impact on freshwater.
- Generate interest for irrigated vegetable farming among women.
- Assist young women with the necessary training and tools/equipment to build knowledge on rainwater harvesting system.
- Train on operation and maintenance system for business venture.
- Train the focused group to become change agents to mobilize the community.

Key activities,

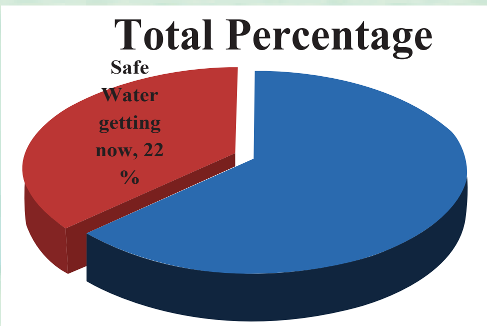
- Site selection
- Identification of the potential young women entrepreneurs
- Training of the young entrepreneurs in operation on RWH system and homestead green gardening.
- Installation of the RWH system
- Monitoring and evaluation.

Findings

a. Qualitative

26 samples collected from project area. The Outputs of the Survey is as follows;

- Severe water poverty exists in the area,
- Water Poverty among young women's household is around 78



• Scarcity and availability	•
• Need safe water per day (n=26)	• 100%
• Not getting safe water	• 78%
• Getting safe water per day (n=26)	• 22%

b. Seasonal safe water scarcity and availability situation analysis.

Season	Seasonal availability	Seasonal Crisis
Summer	5.%	94%
Rainy Season	97.%	2.4%
Autumn	18%	82%
Late Autumn	3.%	96%
Winter	1%	98%
Spring	1.0%	99%

c. Present sources of water collection:

Alternative Sources of water (except rain water)	Percentage
Tube well	24%
Ponds water	76%

d. Socio-Economic Findings

- **Walking Not Studying**
  - Young women are responsible to collect water for the household
  - School and college attendance for young women in the region is going down and the dropout rate for young women is increasing.
  - Women are not allowed to take part in decision making discussion not even at home.
  - Women do not have access to control money for their family.
- **Unprotected surface water Stimulates spread Water Borne Diseases**
  - Due to increasing levels of contamination in nearby surface water sources, people are starting to suffer from water borne diseases, specially the vulnerable group: Children and Women. Salinity in water prevents vegetable production.
- **Salinity Increases Existing Poverty**
  - Due to salinity intrusion people are migrating from their working fields and in most of cases becoming unemployed for a long time.
- **Salinity is a serious Threat to Food Security**
  - Due to high salinity crop agriculture has been seriously affected threating food security.
  - Crops fields are not producing cash crops, cereals and beans that were major sources of vitamins and nutrition for poor families.

Results and Conclusions

- 12 Young Women have Directly Benefited
- 6 Young Women supplied with Locally made rain water harvesting system in their homestead

- Over 300 people indirectly benefited.
- Helped the 6 young women's families to get easy access of safe water
- Stimulated the community to promote and enhance female education, encouraged Homestead Green Gardening and develop
- Entrepreneurship
- Enhanced awareness about the impact of climate change and capacity building on climate adaptation and resilience.
- It is expected that the interventions of the project will Promote Economic Advancement and help to reduce degree of poverty of the trained young women's family.
- The project helped young women to access finance and establish dignity in society and community.
- The project provided knowledge to O&M the system as for business venture.
- Capacity building assisted the focused young women to become change agents to mobilize the community
- The community people are now highly interested about the RWH System and homestead green gardening.

Recommendation

- Monitor the project for at least 2 years to establish its viability as a successful commercial venture.
- Also monitor if drop out of young women from schools have been reduced.
- Observe if there has been positive changes in socio-economic condition of the selected participants.
- Preparation of training modules of further expansion of the program in coming years to cover other coastal zone of Bangladesh.

Community Driven Development approach for participatory water resources management in Southwest area of Bangladesh

Dr. Shamal Chandra Das and Md. Anisul Islam

Introduction:

Geological location and climatology make Bangladesh one of the most vulnerable countries in the world. The Global Climate Risk Index-2018 ranks Bangladesh as the sixth most vulnerable countries from 1997 to 2016 affected by the impacts of weather-related loss. Southwest area of Bangladesh where one fourth of the total population live located in the coastal zone affected by salinity, drainage congestion, cyclonic and tidal storm surge, sedimentation of the tidal channel, arsenic contamination, water shortage due to reduce flow in Ganges tributaries. The southwest area has 78 flood control drainage/irrigation (FCD/I) systems which are not functioning properly due to lack of maintenance, user's ownership, effective inter-agency coordination and community engagement in decision making, planning, implementation, financing, cost sharing (contribute to the O&M) in Water Resources Management (WRM). WRM through an integrated and participatory approach is essential for efficient water management, the sustainability of FCD/I schemes and improved livelihood of the vulnerable poor, including women. With this backdrop, "Southwest Area Integrated Water Resources Planning and Management Project (SWAIWRPMP)-Phase-I" (Fig.1) has been taken to address the issues mentioned above. SWAIWRPMP (Phase-I, April 2006 to June 2015) of Bangladesh Water Development Board (BWDB) in Bangladesh was the first initiative to successfully incorporate beneficiary participation into all aspects of managing large-scale irrigation systems. Asian Development Bank (ADB) and Government of the Netherlands (GON) were the development partners of the project.

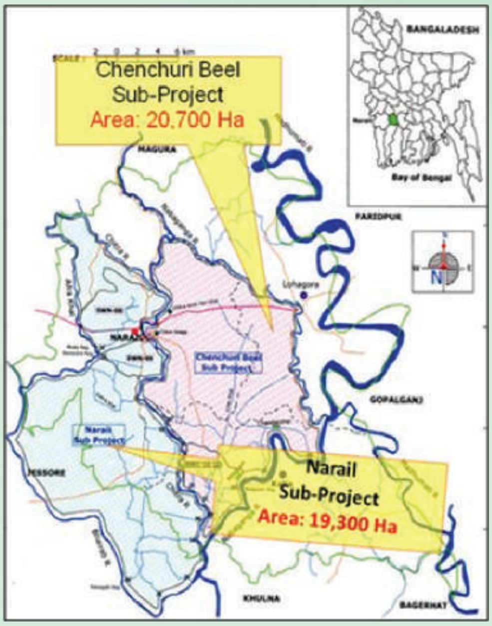


Fig. 1 Location of project in Southwest Region

Objectives:

The project aims to contribute to enhancing economic growth, reducing rural poverty, secure livelihood in the southwest area of Bangladesh by improving productivities and sustainability of selected existing Flood Control, Drainage and Irrigation (FCD/I) systems. Specific objectives of the project are:

- Planning integrated participatory water management system within the hydrological unit;
- Secure and improve livelihood by creating opportunities through participatory water management, including improvement of infrastructure, increase of participation of the be neficiaries and assisting in decentralization (reduce migration),
- Strengthening institutional capacity for planning, implementing, operating, maintaining and monitoring demand driven participatory, integrated water resources management plans;
- Handed over the responsibility of Operation and Maintenance (O&M) of the project infrastructure to the Water Management Group (WMG) constituted with the beneficiaries;

Method:

The project applied integrated community based participatory approach of matching water resources with different users—farmers, fishermen, women, and other users and their needs, which are agriculture, fisheries, livestock rearing, and livelihood development in collaboration with a number of service providers, including the BWDB, the Department of Agriculture Extension (DAE), the Department of Fisheries (DoF), the Department of Livestock and the Ministry of Women and Children Affairs (MoWCA). This direct involvement and mobilization of beneficiaries took a number of forms, including (i) local community participation in preparing the subunit implementation plans; (ii) introduction of income-generating activities new to the project area; (iii) control of lower-level infrastructure by water management organizers (WMOs); and (iv) capacity building through learning-by-doing, particularly in the operation and maintenance of project facilities by WMOs.

Findings:

The project successfully introduced participatory Integrated Water Management Planning (IWMP) with the approach of full participation of stakeholders, potential beneficiaries, local government institutions, local offices of government agencies and established WMOs based on hydrological rather than on administrative boundaries. The project also strengthened the institutional capacity of the members of WMOs in agriculture and fisheries production, income-generating activities, environmental upgrading, gender awareness, improved sanitation and hygiene practices and in managing participatory labor contracts and finally involved community in the operation and maintenance of FCD/I infrastructure in a sustainable way. Water-logging is no longer an issue due to the rehabilitation and reconstruction of water management infrastructure (WMI) resulting increase agricultural and fish production which ultimately improved livelihood and reduced migration.

Impact and results of South West Model Project (at a glance)

Agriculture Achievement: Annual rice production was increased from 72,133 MT to 138,665 MT and annual increased value for rice production was US$ 30.0 million/Tk. 232.86 Crore

Fisheries Achievement: Capture fisheries production was decreased annually by 1747 MT due to lesser open water bodies & improvement of drainage system but culture fish production was increased from 4876 MT to 9773 MT due to better fish/pond management, improved culture technology, better fingerlings etc. Overall annual incremental fish production was 3150 MT and annual increased value was US $ 4.06 million/Tk 31.50 Crore

Livelihood Improvement: Livelihood of the stakeholders/project beneficiaries was improved by 39% against target of 40% through created opportunities for income-generating activities.

Capacity for O & M: Capacity for operating and maintaining flood control, drainage and irrigation infrastructure was increased in a sustainable way through establishment of an O&M system that links the joint management committees with WMAs and WMGs,

WMOs: Formation of 102 WMGs and 13 WMAs with 25,186 members including 9,853 women members and more than 80% of the farmers were enrolled as member of WMGs having 39% women's representation in WMGs.

LGIs: 59 members of the WMOs have been selected as member of the local Government Institutions (LGIs) among them 5 are women.

FFS to enhance knowledge on modern agriculture

Beneficiaries engage O & M activities

Duck farming business

Farmers Field School (FFS)

Fig. 2 Examples of community driven activities in SWAIWRPMP

Significance of the works for policy and practice:

The project had been facilitating inclusive growth in Bangladesh by improving productivity in the agriculture and fisheries sectors in the project areas through increased community participation and has greatly increased capacity of O & M of FCDI infrastructure. It is the first initiative in medium and large scale areas where beneficiaries are directly involved in planning and developing indicatives. BWDB acquired experiences to make the operating PWM sustainable. Institutional set up for PWRM and O&M sustainability is also enhanced through the established of joint management committees in line with National Water Policy 1999 and BWDB Act 2000. The results achieved in the project justify favorable consideration of a follow-on phase and second phase of the project has been initiated based on the lesson learned of the first phase.

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Healthy Nature: Sustainable Water

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Nature and Water Availability

Nature is everything that was not made by man. Nature is defined as the natural Earth and the things on it. The trees, forests, birds, animals and water are all an example of nature. Simply, Water means a colourless, transparent, odourless, liquid which forms the seas, lakes, rivers, and rain and is the basis of the fluids of living organisms. Nature is both as the source of water and also an important water user.

Water is the center to lives, livelihood and development. Everyday we use water for different purposes to fulfill our daily basic requirements. But where does the water we use come from? Just from a simple tap, yes, or from a well, an aquifer or a river or any other water reservoirs. But, behind all these, the ultimate sources are the nature. It is the nature, which cycles, stores, cleans and releases the freshwater that we use. It meets our thrusts, keeps us healthy and fed, and that powers industry and the economy of the country and regulate the ecosystem come to us via nature through a system called water cycle.

Figure: The Water Cycle: the cyclic dependency of water and nature

Water, Nature and Ecosystem services

The benefits people receive from nature are called 'ecosystem services'. The degradation of ecosystem services could grow significantly worse during the first half of this century and was an important barrier to achieving the Millennium Development Goals MDGs). Now in achieving the Sustainable Development Goals (SDGs), we could never do the same mistakes again. Nature includes forests, aquifers, soils, lakes and wetlands provide water storage. Wetlands, forests and soils filter water, rivers and floodplain provide conveyance and transportation, Mountains, floodplains and wetlands lower flood peaks in downstream cities, while mangroves, coral reefs , barrier islands and natural ecosystem protect coasts against storms surges and inundation. Natures recycle

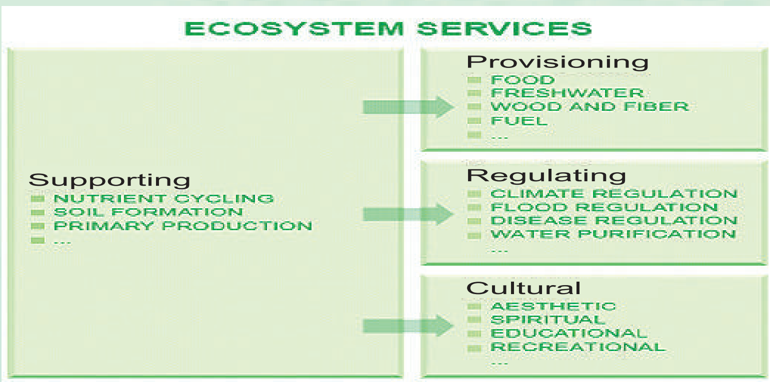

Figure: The Ecosystem Services: The benefits people obtain from ecosystems and absorb excess nutrients and thus reduce water pollution and ensure supply of quality water for mankind. All of these services from nature contribute to water availability in terms of quantity and quality.

Green and Grey Infrastructure and Nature

Nature, through these ecosystem services, provides critical water infrastructure called natural infrastructures or "Green Infrastructures". On the other hand conventional manmade engineering infrastructure called "Grey Infrastructure" are often cost expensive. The 'Green infrastructure' complements augments or replaces conventional built infrastructure so called "Grey Infrastructure" like reservoirs, dams, levees and canals. The natural infrastructure provided by ecosystems is usually highly beneficiary, cost-effective, and its restoration can provide attractive returns on investment in terms of social, financial and economic returns.

Only Green Infrastructure cannot guarantee water availability for people – protection from water based disaster, access to the clean, safe water need for health, livelihoods and production. Both Grey Infrastructure and Green infrastructure are needed for efficient and effective management of water resources. Arrangements for water governance therefore must emphasize nature centric water resources management and development integrating both green and grey infrastructure. Empower the local people to build and negotiate integrated solutions for water management is prerequisite.

Water Solutions from Nature

Nature is the root for all water solutions. But it should carefully in mind that nature can only continue to deliver its services where ecosystems are healthy and well functioned. As we use and divert water, we must ensure the adequate water for ecosystem. This minimum requirement of water for nature is also called "Environmental Flow". Nature is both the source of water and also an important water user. Where this is not recognized, biodiversity is harmed and people lose the multiple benefits that nature provides. Integral to water security therefore is 'water for nature and nature for water.'

Nature based Water Resources Management, Valuing of water-related ecosystem services – to people's well-being, to food and energy security, to industry, the economy and to the drivers of economic growth in cities – make nature a fundamental building block of water security. Failure to account for, invest in, protect and sustain nature, subsequently it will undermines water availability and ecosystem services.

Nature Based Solutions and the Sustainable Development Goals (SDGs)

Nature based solutions for managing water supply and ensures water quality will obviously help to achieve the all targets in SDG 6: to ensure availability and sustainable management of water and sanitation for all. Besides SDG -6, the nature based solutions can also Play important role in achieving other SDG targets i.e. Goal 1: No Poverty, Goal 2: Zero Hunger, Goal 3: Good Health, Goal 7: Affordable clean energy, Goal 9: Industry, innovation and infrastructure, Goal 11: Sustainable cities and communication, Goal 14: Life below water and Goal 15: Life on land. Thus healthy nature will ensure water and subsequently ensure the achievement of SDGs.

Conclusion

Nature and Water is integral to each other. Any beneficial or adverse actions on each other impact simultaneously on both. If we pay proper attention for nature's services and act wisely, nature will be a source of solutions for all water based problems. Because of nature's key role in supplying water and maintaining water quality, we need to commit and continue to supporting action to protect and sustainably manage ecosystems. Protection of nature means secure water.

Finally, natures are like the heart of the world, as they regulate the water to drive the ecosystems that make the world healthy and function properly. However, we have hardly begun to identify the economic possibilities and need to do much more to explore all the potential. Through pursuing this, we can create useful and environmentally healthy natures which are able to ensure sustain water, and create win–win scenarios combining better nature management and sustainable water development for future generations.

Water Scarcity in Bangladesh: Circular Means of Solutions

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Introduction

Bangladesh, despite being one of the few countries in the world with abundant of fresh water availability during rainy season, but also suffers from scarcity due to its high variability over time and space. Seasonal character of water scarcity in Bangladesh is prevails. Availability of water between dry and wet seasons is highly uneven. Challenge is to ensure availability through balancing scarcity. Lack of direct control over the water resources generated in the upstream of the trans-boundary rivers and its equitable share of the country as a lower riparian country is a issue of great concern. Quality of the water is deteriorating as a result of extreme pollution caused by uncontrolled industrial and domestic waste disposal in the system without treatment. A large part of the water resources in the coast are continuously affected through salinization; shallow groundwater is also contaminated by arsenic almost over the entire coast. As a result water has become a limiting factor as well as a critical opportunity for development in Bangladesh. Circulars means of solutions includes Reduce, Re-use and Retention of water for balancing water demand and reduce scarcity over time and space would be significant means of solutions of the problems.

Water Use and Water Scarcity: Global Perspective

According to MDG Report 2015, worldwide fresh water resources are abundant, with only 9% withdrawn by society. However available resources are unevenly distributed across regions and within countries. In 2011, 41 countries experienced water stress, of which 10 withdrew more than 100% of their renewable energy resources. Water scarcity - both Physical and Economic is currently affecting more than 40% of the global population. Physical water scarcity prevails when more than 75% of available water resources are withdrawn; it results from inadequate water resources to meet the demand. On the other hand Economic Water Scarcity prevails when malnutrition exists, although less than 25% water resources is withdrawn. As per World Water Development Report 4. (WWAP), March 2012, conditions for Water Stress: <1,700 m3 /person/yr; Water Scarcity: < 1,000 m3/person/yr and Absolute Scarcity or Water Crisis: <500m3 /person/yr as defines. At present around 700 million suffer from water scarcity. While By 2025, 1.8 billion people will be living with absolute water scarcity, and two-thirds of the world's population could be living under water stressed conditions.

Water Use and Scarcity in Bangladesh: Nature of the Problems

Water demand in Bangladesh is increasing due to population growth, economic development and rapid trends of unplanned urbanization. As the potential for development of new sources of water diminishes, the efficient use of water is necessary to meet future demand. Till now ground water is the main source of water for domestic as well as agricultural and industrial use. Groundwater Extraction is approximately 30 Bm3. Major draw down of water tables occurs particularly in drought-prone zones is now an issue of great concern. Seasonal character of water scarcity in Bangladesh is highly variable. Availability between dry and wet seasons highly uneven .Challenge is to ensure availability by balance the scarcity through technical, economic and behavioral means. Managing the surplus and deficits between seasons is critical through increased supply and reduction in demand. On an average (1975-2012), the total external renewable surface water resources available in the country are around 207 Bm3 during Nov-May, while it is 122 Bm3 during critical months from January to May (Figure 1).

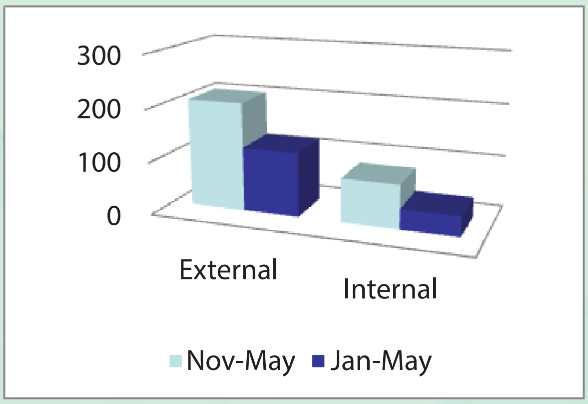

Figure 1: Total renewable water resources in Bm3 from external and internal sources

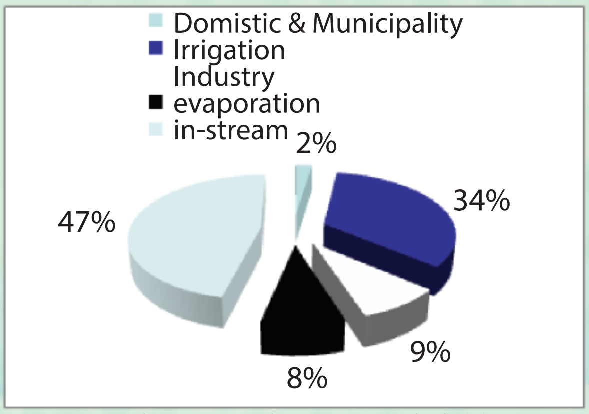

Figure 2: Sector wise water consumption in (%)

Overall Water Stress situation in the country

The total renewable water resources during January-May is 184 Bm3 (More than sixty percent of the water resources is external); Total consumptive usages is 50.5 Bm3 includes domestic and municipality (2%), Irrigation (34%), Industry(9%), and other non consumptive use is around 50 Bm3;includes environmental need/use(47%) and evaporation (8%) (Figure 2). According to World Water Development Report 4, World Water Assessment Programme (WWAP), March 2012condition for water stress: <1,700 m3 /person/yr. Currently in Bangladesh total water resources availability during dry period is 1150 m3 per-capita. Which is 550 m3 per-capita lower than the standard of WWAP water stress. Thus Bangladesh is facing the water stress during dry (January to May) period.

Circular Means of Solutions for Water Resources: Reduce, Re-use and Retention

Circular means of solutions for water management can improve the situations of water balance for a particular region. This circular solution helps in balancing water shortages through reducing water demand and increasing water availability through water re-use, recycle or retention measures. There are many potential circular water measures may be applicable for Bangladesh. Some of them are:

Reduce water losses

High percentage of system loss in water supply is a common practice in Bangladesh. On average, up to 40% of water in Bangladesh is lost in the system because of leakages, but in some regions losses are even higher. The Dhaka Water Supply and Sewerage Authority (Dakha WASA) aims to reduce water losses to 11% by 2035. Agriculture is one of the major sectoral users of the water. About 19% of the growth of the economy is contributed by agriculture. Water demand in agriculture could be reduced by applying simple techniques i.e sprinkler and drip irrigation. The Northwest region has the largest irrigated area among the regions supplied mainly by shallow tube wells. Groundwater levels are declining as a result. In the coastal zone, overexploitation of fresh water is causing salinization of the shallower aquifers. Sustainable water pumping considering aquifer health is a circular water measure with significant potential in Bangladesh. Practicing crop rotation and introduction of less water demanding crop, saline tolerant variety in coastal areas could enable the use of less water for irrigation. Increase water use efficiency in Industries has the potential to reduce both water demand and production costs. Experts opined that there are opportunities to reduce water use by up to 20% at a relatively small cost. Most houses do not have access to tap water; the potential to reduce municipal water demand through reducing system loss.

Reduce water pollution

The National Water Policy 1999 emphasize polluters pay principal for reducing water pollution and it is a key guiding element in making the water cycle more circular. As per BDP, "Water quality and pollution is a one of the key issues in Bangladesh, causing not only health hazards but even contributing to casualties during floods. Sources of pollutants include municipal waste, dyeing industries, chemical plants, tanneries and refineries. The use of fertilizers, herbicides and pesticides also results in pollution of water in agricultural areas. In general, water quality of the surface water is within acceptable limits during the monsoon period. During long dry spells however, water quality deteriorates."

Re-use of water

Re-use of water is very limited in Bangladesh. Poor water quality is often a important barrier. As a result, treatment of water and make it suitable for reuse is crucial to build a more circular water system. About less than 10% of the total domestic sewage is currently treated. The main treatment plant operates at only about 30% capacity due to system failures. The remaining sewage is often discharged directly into open water bodies. Dhaka WASA is planning to construct six new surface water treatment plants by 2035. Hope that the situation will be better if the planned treatment plan will be in function.

Retention of water

Attitude to construction of Big Dams/Barrages are most common practices to water retention measures in the country but, due to their environmental impact, these are not considered as circular water measures. Rainwater harvesting specially for coastal areas shows great potential. Other potential forms of water retention includes managed aquifer recharge, excavation and re excavation of natural and artificial water reservoir, dredging of rivers, conservation of Watersheds, Reduction of ecosystem degradation and planned afforestation, Preservation of Big ponds, digies and communal water bodies for increase water storage to manage the water scarcity for multipurpose use has the significant potential in Bangladesh.

Conclusions

The water supply of Bangladesh shows large seasonal fluctuations as most of its annual precipitation occurs during the monsoon season. There is a periodic cycle of access and scarcity of water resources. However having available water in the country during the rainy season, but the country has to face scarcity during the dry period. However equitable share of transboundary water is one of the significant barriers, but judicious uses of available water is most important for sustainable development. With increasing demand of water usages, fresh water resources availability /accessibility are likely to decrease under business as usual condition and there is a clear sign that stresses will be evident locally. The threat of climate change, sea level rise and upstream withdrawal, water scarcity is likely to further aggravate. However to a great extent the scarcity of water, conflict among its competitive users, pollution of the surface and ground water resources are predicted because of the inefficient and inequitable ways the resource being governed and managed. Appropriate planning including potential circular means of solutions for Water Resources i.e Reduce, Re-use and Retention, ensuring good governance and its implementation hopefully improve the water shortage problems in the country.