Capacity Development Project on Safe Use of Wastewater in Agriculture

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ABSTRACT

Untreated municipal wastewater is being traditionally used for agriculture by the farmers in the peri-urban areas of Bangladesh, located in the drought-prone north-western part of Bangladesh. This study was carried out to identify the benefits, adverse impacts, social acceptance and a long term institutional arrangement of wastewater reuse in the peri-urban areas. Questionnaire surveys were conducted in the exposed and control sites to collect data on the farmers' perception and responses regarding the agricultural, economic, social, environmental and health issues. Also, a total of 12 wastewater and groundwater samples were collected from the exposed and control sites for quality analysis. Water analysis results show that all the parameters analyzed to assess wastewater quality, expect BOD, do not exceed the WHO recommended limit for irrigation.

The most important benefits of wastewater reuse have been found as the availability of wastewater over all seasons and reduced chemical fertilizer requirements in crops field. Yield performance and economic return has been found higher in the study sites than that in the control sites. Cropping intensity is also found to be higher in the study sites than that of control sites. On the other hand, the potential risks of wastewater reuse have been found as the increased pest attacks and crop diseases and health incidents of the farmers. About 25% respondents in the wastewater reuse sites reported health problems such as allergy and skin diseases. They also commented that mainly medical and industrial wastewater is causing these health problems. Farmers and their neighbors reported that, wastewater spread over agricultural lands pose significant odor problem, though most of them are used to it. Sometimes excess wastewater used for irrigation short-term water logging in the area which eventually leads to crop damage.

The farmers reported that the crops grown with wastewater irrigation are socially acceptable as they do not face any difficulties to sell them in the market. Interviews with the key actors indicate that a long term institutional arrangement for sustainable reuse of wastewater is feasible in the region.

Water availability and use:

Bangladesh is situated in the most downstream part of the Ganges Bhramaputra Meghna (GBM) basins. Because of its unique geographical location and topography, it is one of the most flood prone countries in the world. Approximately 20 to 30% area of Bangladesh is inundated during the monsoon season in average flood condition and at least 50 to 70% area oh the country is exposed to intermittent extreme flooding that has far-reaching negative impacts on the national economy. Flood management in Bangladesh is, therefore perceived as an indispensable component of poverty reduction initiatives.

The Country has a unique hydrological regime. Bangladesh generally experiences four types of floods. Flash floods occur during mid-April before the on-set of the south-westerly monsoon. Rain-fed floods generally happen in the deltas in the south-western part of the country and are increasing in law-lying urban areas. River floods are the most common; the areas are inundated during monsoon season along the river and in cases far beyond the riverbanks. Strom surge floods occur along the coastal areas of Bangladesh. Coastal areas are also subjected to tidal flooding from June to September. During the last Half-century, at least eight extreme flood events occurred affecting 50% of land area. When water levels in the three major river systems rises simultaneously and cross the danger marks (usually starting from mid-July and continuing until mid-September), an extreme flood situation usually occurs all over the country . Duration of these extreme events normally extends from 15 days to 45 days, This was observed during those which occurred in 1987, 1988 and 1998 , the latter having been the severest one in terms of magnitude and duration.

A Summary of irrigation by different modes used in 2010 is shown bellow.

Table 1: Summary of Irrigation by different modes used in 2010

Sl. No.	Mode of irrigation	No. of equipment	Area irrigated (ha)	% of total irrigated area	Area irrigated per equipment (ha)
A. Irrigated through utilization of surface water by					
1	Low lift pump	150613	964902	18.50	6.41
2	Gravity flow	0	85151	1.63	
3	Traditional method	0	40186	0.77	
Sub total		**150613**	**1090239**	**20.90**	
B. Irrigation through utilization of ground water by					
1	Deep tube well	32912	773323	14.82	23.50
2	Shallow tube well	1425136	3336652	63.95	2.34

3	Manual & Artesian well	0	17412	0.33	
	Sub Total	**1458048**	**4127387**	**79.10**	
	Grand Total	**1608661**	**5217626**	**100%**	

Source: MOA, 2010

From the table, it is also revealed that 20.90 % of the total dry season irrigated area is covered by surface water and remaining 79.10 % is covered by groundwater irrigation. On the other hand, 63.95% of the total irrigated area by STWs. These STWs are owned and operated by small and marginal farmers. But due to global warming, climate change and unplanned withdrawal of groundwater, STWs of about 23398 sq areas cannot pump sufficient water during March and April due to rapid groundwater depletion.

Wastewater production and treatment:

Wastewater irrigation has recently emerged as a focus of study in the developing world where its use by urban and peri-urban farming communities is increasingly becoming popular (Rutkowski *et al*., 2007). Wastewater may supply organic matter and mineral nutrients to soil that are beneficial to crop production, and reduce the cost of fertilizer application. In arid regions, wastewater is especially valued as an additional resource besides the added benefits from its nutrient contents (Van der Hoek *et al*., 2002). However, urban wastewater may also contain hazardous substances including heavy metals and pathogenic micro-organisms (Siebe and Cifuentes, 1995; Flores *et al*., 1992). These substances may eventually harm the environment, human health, soil, groundwater and crops. So any decision-making related to wastewater reuse should consider both positive and negative aspect (Haruvy, 1998). Many countries have developed guidelines and quality criteria of wastewater reuse for agricultural irrigation. Examples of these guidelines are summarized in the USEPA manual of wastewater reuse (USEPA, 1992). WHO (1989) also provides a guideline and quality criteria for the reuse of wastewater for various purposes. In Bangladesh, still there are no such guideline and quality criteria for wastewater reuse in the urban and peri urban areas.

In Bangladesh wastewater agriculture has been a traditional practice in the peri-urban areas. Wastewater is lifted from these canals for irrigation and aquaculture ponds. Although farmers enjoy direct economic benefits from this wastewater reuse, residents in these areas have complaints of diseases and degrading air and soil quality. A sewage treatment plant for the City Corporation area is planned to be constructed by 2010 (WARPO, 2001). If wastewater reuse can be managed under an institutional arrangement between the City Corporation and local water users, effluent from this plant can be used to support agriculture in the peri-urban areas. The benefits, risks and social acceptance were assessed in this study for sustainable management of wastewater reuse in the peri urban areas.

Wastewater use/disposal: In rural and peri-urban areas of most developing countries, the use of sewage and wastewater for irrigation is a common practice. Wastewater is often the only source of water for irrigation in these areas. Even in areas where other water sources exit, small farmers often prefer wastewater because its high nutrient content reduces or even eliminates the need for expensive chemical fertilizer.

Concern for human health and the environment are the most important constraints in the reuse of wastewater. While the risk does need to be carefully considered, the importance of this practice for the livelihoods of countless smallholders must also be taken into account. The aim of IWMI research on wastewater irrigation is to maximize the benefits to the poor who depended on the resource while minimizing the risks.

Many wastewater irrigators are not landowning farmers, but landless people that rent small plots to produce income –generating crops such as vegetables that thrive when watered with nutrient-rich sewage. Across Asia, Africa and Latin America these wastewater micro-economics support countless poor people. Stopping or over –regulating these practices could remove the only income many landless people have.

Affluent countries regard wastewater treatment as vital to protect human health and prevent the contamination of lakes and rivers. But for most developing countries this solution is prohibitively expensive. In this case, applying wastewater to agricultural lands is a more economical alternative-and more ecologically sound than uncontrolled dumping of municipal and industrial effluents into lakes and streams.

Extensive wastewater agricultural has been practiced by the peri urban farming community since 1976 and the farming community does not face any legal restriction of using polluted water from the wastewater drain. All farmers in the expose site like to use wastewater because of the least water and fertilizer cost, and scarcity of freshwater for their crops. About 90% farmers commented that use of wastewater is reliable for their crops, while 70% reported that they could keep the fertilizer cost to minimum due to using wastewater. The survey results revealed that 90% farmers in exposed site do not face any water shortage and wastewater is available and sufficient round the year. Only 10 % farmers living lower end of the waste water drains commented that they face a little water shortage during the month of the March-April. The most relevant cause of this water shortage was the reduction of canal flow due earthen water canal and extensive water uses in the upstream. As wastewater is available and sufficient round the year in the exposed sites cropping intensity is high in comparison to the control sites where fresh water is used. In exposed sites vegetables are the most chosen crop (70%) by the farmers where as in control site rice (40%) is the most chosen crop to the farmers.

Policies and institutional set-up for wastewater management:

Integrated planning and management requires understanding of the natural and physical processes of the water resources system. This requires appropriate tools and technologies to support decision making that would help in evaluating different strategies or options for water resources management. The Need for such analytical tools was first recognized in early eighties during the preparation of the water sector master plan. Mathematical models are such analytical tools in decision support and to simulate the physical process in nature, over the next one and half decade, a mathematical model of entire surface water system including the Bay of Bengal was developed in IWM (erstwhile SWMC). These models were used extensively in Bangladesh in the solution of Different water related problems.

Institute of water Modeling (IWM) provides support in hydrological assessments, designing of hydrological monitoring networks and information systems, flood mapping ,floods risk and damage assessment, real-time flood forecasting and operational water management systems, land use and climate change studies and flood mitigation planning, design and operations of hydraulic structures utilizing the mathematical models .The centre has cutting edge technology, modeling tools on flood management, flood forecasting and climate change issues . The main strength is its sound experience in maintain and updating of all the Regional Models including the General Model developed under the three phases of Surface Water Simulating Modeling Programme. One of the strengths of the specific division (FMG) is its technical capacity to support the FFWC of BEDB in its routine flood forecasts during the past decades, also conducting research for increasing the land-time.IWM has recently developed the Ganges Brahmaputra Meghna (GBHM) basin model capable to increase the lead time of flood forecast s as well as a tool to see the climate change impacts and make water resources assessments on a regional context.

The agriculture production plan of the Government lays major emphasis on the development and efficient utilization of water resources. This involves both structural and non structural’s measures. The National Water Policy enunciates involvement of communities and individuals and public and private sectors in water resources managements. The Guidelines for Participatory Water Management approved in 2000 indicate how the local stakeholders and private and public sector agencies will work together for community water management. Opportunities and potentials for increasing agricultural productively in the country depend on participatory water recourse management activities which include irrigation, drainage and flood management.

Frequent incessant rainfall within the urban areas creates urban flooding which has a serious consequence for a city like Dhaka, because of its dense population and increasing unplanned urban growth. Flooding or Drainage congestion, water supply and sanitation problems are some of major issues faced by the city dwellers, During the monsoon, flooding in the city occurs due to river flood and excessive rainfall. Inadequate drainage system, illegal encroachment of the natural drainage areas and flood plains aggravate the situation. Lack of technical, social and institutional capacity and resource unavailability causes management problems. Water related problems in terms of availability and quality pose a huge threat to city dwellers life. Risk of some diseases, during and after flood is vector-borne diseases like malaria, dengue fever and waterborne diseases like diarrhea. Dengue has emerged as one of the acute illness in the three major cities (Dhaka, Chittagong and Khulna) of Bangladesh with the highest incidence in Dhaka, which is likely to increase in future. Urban city dwellers both the rich and poor communities are susceptible to urban flooding related problems which will be worsened and thus need to be considered in lieu of climate change scenario.

Against this backdrop, CEGIS in association with Ritsumeikan University of Japan and BUET has initiated a research project to evaluate the climate change impacts on the water resources and environment of Dhaka city to ensure water environmental security taking into consideration the Integrated Water Resources Management (IWRM) approach. Special focus has been placed water pollution etc.

Research/practice on different aspects of wastewater: The impact of global warming on environment is becoming evident day by day. Glaciers on the Himalayas and Polar Regions are melting at an alarming rate. Sea level has started rising already vanishing many small islands in recent times. The island of Talpatti in the Bay of Bengal does not exist anymore. Seasonal variation of climate has become almost non-observable. Previously Bangladesh used to enjoy six distinct seasons. Now it appears that only two seasons exit-hot and cold wave, depression in the sea etc. are now too common. Such unusual changes in climate are causing havoc to bio-physical and socio-economic environment of the country.

Water : Salinity of rivers is also increasing. Data Collected by DoE shows that peak salinity of rivers around Khulna city in 2009 increased by at least 2.5 times compared to 2005. Such increases in salinity are a threat to water supply, river ecosystem and Sundarbans. In anticipation of the increase in salinity due to climate change, the recently initiated Khulna Water Supply Project has set higher water storage area as an adaptation option.

Health : This is generally assumed that the prevalence of heat stress, diarrheal diseases and aggravation of cardiovascular and respiratory diseases will increase during extreme temperatures and heat waves in Bangladesh. The seasonal peak of diarrhea in Bangladesh corresponds with the period of higher bacterial growth caused by high temperatures. The number of reported cases and deaths in 2009, was double than that of the previous year.

Climate Change is likely to have major impacts on outbreak of malaria, dengue and other vector borne diseases. Changes in environmental temperature and rainfall will increase vector-borne diseases into temperature region like India and Bangladesh. The presence of dengue in Bangladesh was unknown before 2000. The outbreak started in summer of 2000 and since then every year some cases are being reported.

Yield, economic benefits and farmers' perception

Van der Hoek *et al.* (2002) reported that, untreated wastewater increase the crop production and also minimize fertilizer and water cost. Similar characters were found in this study. It was found that, in the exposed sites crop production and economic return always higher than that of control site (Table 3). Economic benefits were found due to higher agricultural production which is as high as up to BDT 86, 275/ha from spinach production. This result explain that why 70% farmers in the exposed sites like to grow vegetables in their field.

Survey results show that about 55% out of 70% respondents who prefer to grow crops in the exposed sites, like to produce vegetables because of the high demand of vegetables in the city market and more economic benefit than that of other crops. These farmers commented that they like to grow vegetables because when grown with wastewater, vegetables become healthier, colored, and attractive therefore easy to sell in the market even from field. Moreover, about 20% of the mentioned 70% respondent told that they like grow vegetables in wastewater because of quick production cycle and high economic benefit which also save them from purchasing extra vegetables for their families.

Table 2: Comparison of agricultural production and economic benefit between wastewater and freshwater Agriculture

Crop A	verage Production Tons/ ha			Market Price/kg	Economic Benefit (BDT)	fertilizer Cost Saving/ha	Cumulative Econom ic Benefit
WW		FW	Difference				
BR 28	6	5.5	0.5	20	10,000	2126	12,126
Wheat 3.	2	2.5	0.7	35	24,500	2024	26,524
Maize 15		12	3.0	10	30,000	2148	32,148
Spinach 40	.41	30	10.41	8	83,280	2995	86,275
Papaya 36		28	8.0	8	64,000	2360	66,360

Note: WW=Waste Water; FW= Fresh Water

Bangladesh National Committee if ICID was established in 1973 under the Ministry by the eminent water Resources, Government of Bangladesh. The members are appointed from different organizations, activity engaged in the fields of Irrigation, Drainage, Flood Control, River Training Works and other Water Related activities including one representative from the Ministry. The 18 members present national committee represented by Director General , Bangladesh Water Development Board as ex-officio Chairman and Director ,Joint Rivers Commission as the ex-officio Member –Secretary of BANCID.

Institutional and legal aspect is one of the key issues of planning and management of agricultural reuse projects (Lazarova *et al.*, 2000). Lack of the institutional setting and guideline or measures may fail the reuse projects. Thus, Institutional setting may be an important tool for public acceptance, long tem sustainability and willingness to implement of any reuse project.

Status and need for the knowledge and skills on the safe use of wastewater:

Impact on Public Health

Many farmers (75%) of the exposed sites reported that they do not face any health problems while using waste water for irrigation continuously because they are adapted to handle wastewater for a long time (more than 10 years). However the rest of the farmers (25%) informed that they face some health problems during wastewater handling. Allergy (25%), skin infection (25%), vomiting (17%) and headache (10%) are the most occurring cases in wastewater sites. On the other hand in control site no such health problems were reported by
the farmers, only 7% reported minor headache and 5% reported allergy problems. Among wastewater farmers, 70% of the respondents revealed worries about the risk of medical waste
such as needle, blade, pathogens, plastic saline bags etc.

It has been found that, in both wastewater and fresh water sites, farmers do not take any preventive measure during handling water for their crops. However, in wastewater sites 60% of the respondents informed that they take some form of preventive measure while handling wastewater. Usage of soap and mustard oil has been found a very common measure to reduce allergic problems among the water water farmers.

The average medical costs were found as slightly higher among the wastewater farmers.

While 50% of the wastewater farmers spend BDT 50-100 per month against medical purposes, 65% of the fresh water farmers were found to spend less than BDT 50 for the same purpose.

Conclusions :

Affluent countries regard wastewater treatment as vital to protect human health and prevent the contamination of lakes and rivers. But for most developing countries this solution is prohibitively expensive. In this case, applying wastewater to agricultural lands is a more economical alternative-and more ecologically sound than uncontrolled dumping of municipal and industrial effluents into lakes and streams.

Obviously the short –term benefits of wastewater irrigation could be offset by the health and environmental impacts. The first step is to scientifically evaluate these.

Once the actual risks are clear, we can work to reduce them. This means, for example, finding affordable ways of monitoring the presence of harmful contaminants in wastewater, such as heavy metals that can accrue in soil and crops. It means looking at farming practice and crops grown to find ways of minimizing risks of infection for farmers and consumers.

IWMI's research in Pakistan, Ghana, Vietnam and Mexico examiners both positive and negative impacts of wastewater reuse for agriculture. This work will result in tools and concepts that can help policy makers and planners balance the needs of small farmers with the health of people and the environment.

The present study suggests that, availability of wastewater has increased the opportunity of cultivating crops like vegetables in the semi arid region like Rajshahi and that is why waste water is a valuable asset for the local farmers. Reuse of wastewater has an increased benefit due to higher crop production and less fertilizer cost. Wastewater assimilation is also a major benefit of wastewater reuse as there are no treatment facilities. On the other hand, incidence of pest and crops diseases, excess weed in the crop field and health impacts such as skin diseases and allergy are found to be some major disadvantages of wastewater reuse in Bangladesh. The water quality result shows that, only BOD level was unacceptable for agriculture and aquaculture reuse.

Analysis of social acceptability of untreated wastewater reuse revealed that it is socially acceptable by the both farming and non farming community. Feasibility analysis of an institutional arrangement indicates that a long term institutional arrangement is possible though initiatives concerned authority and this will increase more opportunity in the future with less health and environmental incidence of the farmers and local community.

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