# Title: **International Environmental Issue between India and Bangladesh: Environmental and Socio-economic Effects on the Teesta River Area.**

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*Abstract:*

In most countries of the third world, where decolonization has taken place, oppression has found its new forms. Political and economic instability, slow growth as well as uneven and unreasonable sharing of natural resources with the neighboring countries present an acute struggle for survival. Sharing water of the Teesta River in Bangladesh and India is an example of this kind of struggle. Although the name -Bangladesh has almost become a synonym for natural calamities, which are beyond the control of men, several man-made obstacles, like the Farakka and the Teesta Barrage have tremendous negative influence on the agriculture, navigation, fisheries, forestry etc. of the north-western part of Bangladesh. This paper is an attempt to demonstrate a pen-picture on the people of the Teesta River basin based on primary data. The paper also attempts to focus on the trend of average loss of land, income level and other socio-economic phenomena, which show that, natural as well as man-made calamities, together account for the backwardness of socio-economic development in Bangladesh. The main target of this paper however, is to generate data in order to formulate a profile of an optional development policy for the betterment of the Teesta affected people.

## Introduction

Bangladesh is a very small country in The South Asia with an area of 144,000square km.[1] She shares most of her borders with India. Bangladesh is criss-crossed with over 200 rivers and more than 57 river basins are shared by two or more countries.[2] There are many rivers in Bangladesh which have their upstream in India. The Ganges and the Teesta are two important ones.
The idea of using the Teesta River for irrigation is as old as the British period (1935).[3] Most of the area found suitable for gravity irrigation falls in territory of Bangladesh. Due to partition of India (1947), implementation of the project slowed down.* However, both the countries (India and former East Pakistan) started to formulate the project later in their own parameters.

For the Bangladesh territory, the preliminary feasibility report of the project was prepared in 1960 by M/s. Haigh Zinn and Associates in collaboration with A.C.E Ltd. (Pakistan) and Ms. Binne and Partners Ltd. prepared the second one. During 1968-70.[4] After the independence of Bangladesh the Government gave a serious thought into the undertaking of the project. The

* Under British colonial rule, present India, Pakistan and Bangladesh were recognized as greater India. At the end of the British period (1947), partition of India took place, creating two independent countries-India and Pakistan. At that time, the area of present Bangladesh fell under Pakistan-being termed as East Pakistan. In 1971, Bangladesh become independent through a liberation war.

Barrage was completed successfully in August 1990. The irrigation facilities were provided from January 1993 and during the year an area of about 65000 bigha (16000 acres) was brought under High Yielding Variety (HYV) paddy cultivation in the dry season. The project was also being implemented for flood control and drainage for a command area of 750,000 hectares, of which 540,000 hectares were irrigable. The project covered seven districts of northern-Bangladesh. In the meantime, India constructed a Barrage over the Teesta which is 100 km. upstream of the Dalia Barrage* (Bangladesh) site. [5]

In the rainy season India departs excessive water through the barrage to the Bangladesh area causing floods. But in the dry season India retraces water from the Ganges and the Teesta River for using in agricultural fields and navigation purposes. In the last 25 and 15 years (respectively) India took water from the Ganges and the Teesta exparetely and the Bangladesh portion had become dry. Lacking in sufficient flow of water in the rivers Padma (in the Bangladesh portion the name of the Ganges is Padma river) and the Teesta, environmental and the socio-economic conditions of the surrounding region has become very severe and the socio-economic and environmental problems of the region are growing day by day.

In this paper we discuss the socio-economic and environmental conditions of the Teesta River basin on the basis of a recent survey. The effect of the Gozaldoba** Barrage on mean monthly discharge of water in the Teesta River, pre and post barrage (Gozaldoba) water flow in dry season, sudden depart of excessive water in the rainy season and chronic deluge in Bangladesh, have also been addressed. Some recommendation regarding the problems has been made.

## Rationale

There is a popular Chinese proverb that "those who govern the water, govern the country"(Okazaki, 1961). [2] In fact, rivers had always played an important role in history and politics throughout the world. The Pharonic, the Sumerian, the Babylonian and the Chinese civilizations were created on the banks of the Nile, the Tigris, the Euphrates, and the Huangho respectively. Bangladesh is a small country, cris-crossed by hundreds of rivers. It is the home of about 120 million people, just under one in ten of humankind and most of them concentrated in the flood plain areas with an agriculture-based economy.

Through the history of the region, the Tista River has had a marked agricultural and economic impact on its adjoining areas and in many ways influenced the life patterns, culture and history of the people. From administrative point of view, the Tista dependent area covers the greater Rangpur district i.e.the present districts of Lalmonirhat, Nilphamari, Rangpur, Kurigram and Gaibandha- starting at the entry point of Bangladesh border with India, to end in the mouth of Brahmaputra. It is the region of 20 million people with a density of 1700 per sq. Mile/700 per k.m. (BSS 1991:23). Agriculturally, "a sub region of paddy surplus with a

*Dalia-the name of the barrage on the Teesta river in Bangladesh.
** Gozaldoba- the name of the Indian barrage on the Teesta river which is 100 km. upstream from the Bangladesh barrage site.

unique home of tobacco rearing..... Landlessness and hungry homes are products of wasted years. But there is no reason why the immiserised population of this resource rich zone should remain poor and hostage to a recurring cycle of damaging flood and drought?(Verghese, 1990)[3]

At present the river bears only negative impacts. Some scholars opine that, these impacts are the result of the barrage made by India on the upstream of Teesta within the Indian Territory. Owing the unilateral withdrawal of water by Indian authority, Bangladesh is getting only 10-15 percent (3-4 thousand cusecs; *1 cusec= 990[2] metric ton of water flow per second*) of total water. The lowest flow on January 13,1998 was 2700 cusecs[4] and on February 24,1998 it was only 850 cusecs.[5] But Bangladesh needs at least 8000 cusecs in the lean season to keep the barrage active.

As far as we know, no effort has yet been made to carry out research on this issue (only the Bangladesh Water Development Board conducted some feasibility studies for the very purpose of the Teesta Barrage Project in 1986). The present study is an attempt to investigate the impact of the barrage made by India at the upstream of the Teesta in its territory on the people of the Teesta basin area Bangladesh, which indeed would contribute to extend our knowledge on this issue.

## The Spatio-physical background of the study area

The Teesta dependent area is one of the largest sub-regions of the Bengal basin, which covers almost the entire greater Rangpur district. In Bangladesh portion, the Teesta flood plain is bounded by latitudes 25 30 to 26.18 N' and longitudes 88.52 to 89.45E' which includes the north-eastern part of the country. It covers the area about 1062 square miles/2,750 km square (Survey of Bangladesh, 1976:507).

Before 1787, Teesta was the main stream of the North Bengal and it is still remains an important river in this region at present. After 1787, the Teesta river has changed its course due to earthquake and a big flood which has had direct and indirect impact on its systems and floodplain.[6] Teesta region is bound by the Himalayan terraces in the north and north-east, the Barind region (which lies in the Dinajpur-Bogra district, characterized by low nearly level to gently undulating, uplifted terrace landscape of low ridges, separated by nearly level areas) in the West and South-west, the Ganges floodplain and the river Jamuna in the South and East respectively.(see the map page-) Teesta is the main active river of this area which is responsible for the active land formation process.

### The Data

This study is based on analyses of both primary and secondary data sources. The primary data have been collected by a field survey and the secondary data have been collected from various agencies as: Water Supply Authority, Bangladesh (WASA); Bangladesh Water Development Board (BWDB); Teesta Barrage Monitoring Office, Dalia, Lalmonirhat, Bangladesh; Ministry of Agriculture Bangladesh; Indian Journal of Meterological Geophysics; Indo-Bangladesh Joint River Commission (JRC 1998) Daily discharge and water-level Data were supplied by the Dalia and Kawnia water monitoring point Authority; Bangladesh Bureau of Statistics(BBS) and Internet libraries & online journals.

The hydrological data sets contained some missing observations, which

were estimated (up to a reasonable limit). In the BWDB discharge set, observations for 1971 were missing.

**Methods**

Three specific types of analyses have been performed based on various data. First, the discharge time-series data for the Teesta River at Dalia point and Kawnia point*** have been divided into pre-and post Teesta Barrage (Gozaldoba) periods. Then monthly mean discharges for the two periods have been calculated.

Second, the possible effect of the reduced flow caused by the Teesta Barrage (Gozaldoba, India) on the Teesta River (Bangladesh portion) has been examined by reviewing the various pumping points, Char (sandy) trends, from the published reports and observations. The corresponding discharge for the Dalia Barrage (Teesta River, Bangladesh portion) has been determined from the monthly linear regression relationship between the monthly mean discharge of the Dalia and the Gozaldoba periods.

Third, the sudden depart of excessive water to Bangladesh portion in the rainy season and the devastation of chronic deluge and, the implication of the reduced water flow on agriculture, bank erosion, forestry, navigation, industry, drinking water and social life were considered based on a recent survey as an exploratory social survey and the data have been analyzed by using various statistical calculations.

## Reduced dry season flow in the Teesta River (Bangladesh) and its effect on crop production:

Northern Bangladesh is a plain land area and 90% of its population rely on agricultural production, depending on nature. Due to lack of water they cannot cultivate the land in the dry season. Every year they face drought and lose a huge amount of crop and hence be hit by mass poverty.

The successful implementation of the Teesta Barrage (Dalia) project was a dream come true for them. The poverty stricken people could now hope for a better future. The trend of increasing in crop production can be shown to the following: -

Table-1

The increasing trend of production after starting the Dalia Barrage

| Crop | Additional land available for crop production $\Delta L_1$ (in hectare, in 1994) | Additional land available for crop production $\Delta L_2$ (in hectare, in 1995) | Period-1 Increased in production $\Delta Q_1$ (in tones, in 1994) | Period-2 increased in production $\Delta Q_2$ (in tones, in 1995) | $\frac{\Delta Q_1}{\Delta L_1}$ | $\frac{\Delta Q_2}{\Delta L_2}$ | Money value increased by one year in US$ |
|---|---|---|---|---|---|---|---|
| Paddy(HYV) | 92,000 | 1,12000 | 6,500 | 48,000 | 0.07 | 0.42 | 8 million |
| Tobacco | 50,000 | 72,000 | 17,00 | 3,000 | 0.03 | 0.04 | 12 million |
| Wheat | 20,000 | 52,000 | 1,200 | 22,000 | 0.06 | 0.42 | 5 million |
| Potato | 10,000 | 12,000 | 20,000 | 32,000 | 0.5 | 2.67 | 0.5 million |

*** Permanent water level measurement points of the Teesta River in Bangladesh.

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Ground Nut | 7,000 | 7,500 | 1220 | 1,860 | 0.17 | 0.24 | 0.3 million |
| Sugarcane | 7,500 | 16,600 | 19,000 | 47,000 | 2.5 | 2.83 | 0.8 million |

The above trend of crop production has been calculated as;

$\frac{\Delta Q_1}{\Delta L_1}$ = Changing rate in production by using additional land in period-1;

$\frac{\Delta Q_2}{\Delta L}$ = Changing rate in production by using additional land in the period-2;

The result shows an increasing trend in crop production using additional lands and its money value increases approximately 27 million US$ in the second year. This trend focuses on only 22% of the total target area. If the total target area (750 million hectare)* can be cultivated, then the average money value will increase into US$ 230 million approximately per year.

## Correlation between paddy production and availability of water in the post Dalia Barrage operation period

Table no-2

| year | Amount of water cusec (W1) | Additional land cultivated in hectare | Amount of crop produced (in tones)P1 | year | Amount of water (W2) | Land cultivated in hectare | Amount of crop produced(in tones)P2 |
|---|---|---|---|---|---|---|---|
| 1994 | 21,000 | 92,000 | 6,500 | 1997 | 7,000 | 45,000 | 32,000 |
| 1995 | 22,000 | 1,12,000 | 48,000 | 1997 | 3,000 | 32,000 | 21,000 |
| 1996 | 21,000 | 1,32,000 | 56,000 | 1998 | 856 | 27,000 | 11,000 |

*The r (W1, P1)=. 91 & r (W2, P2)=. 473*

The above table (5) shows that, after initiating the Dalia Barrage, the target area of the scheme increased and due to availability of water the amount of production also increased in the year 1994-1996. When the Gozaldoba Barrage was started to decline water on the upstream; the Dalia Barrage faces serious shortage of water and the target area become reduced and the amount of production also reduced in the year 1997-1999.

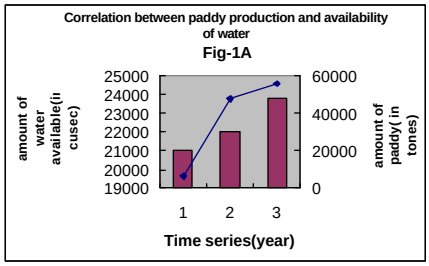
The statistical analyses show that, correlation between W1 (X) and P1 (Y)=. 915 and between W2 (X) a P2 (Y)=. 473 If the "*r*" is shown same then we can assume that, there is no effect on the declining water by Gozaldoba Barrage. But we see that, the "post" *r*-value is less than that of "pre" valued. Thus we can say that *r*-value has decreased as because of declining water on the upstream and there is a positive correlation between the amount of water and crop production.

But this is not actually the true situation.

If "*r*" value increases without available water supply, the result can be

* Manual(1993:3) Teesta Barrage Project, Bangladesh Water Development Board, Dalia, Rangpur

attributed to an association between other factors of crop production. And if the "*r*" value decreases in spite of taking into account the association between the other factors (fertilizer, pesticides, HYV seeds etc.) then we may conclude that, water is the main factor. The following figure shows the relationship between the availability of water and crop production after inaugurating the Dalia Barrage in Bangladesh.



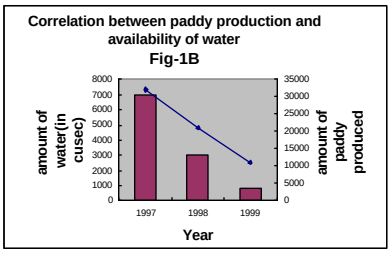




Fig: 1A and Fig. 1B; *Availability of water supply and crop production after starting the Dalia Barrage in Bangladesh.*

The above figures show pre and post water supply after starting the Dalia Barrage and production criteria according to the data of the above table. The star curve shows production series with different amount (values) of production in the pre time (1994-1996). But in the post period the figure shows the decreasing nature. The 1,2,3 in Fig-1A indicate time series as (1994,1995,1996) respectively.

**Comparison between Gozaldoba Barrage (Teesta River, India) and Dalia Barrage (Teesta River, Bangladesh)**

Table no-3

| Criteria | Gozaldoba(India) | Dalia(Bangladesh)* |
|---|---|---|
| Target area | 25,000ha | 750,000ha |
| Irrigable area | 12,000ha | 540,000ha |
| Branch canal | No | 275km |
| Flood embankment | No | 80km |
| Nature of soil | Hilly/yielding crop once a year | Plain/yielding crop thrice a year |
| Potential productivity | Less fertile | Fertile & high productivity |
| Beneficiaries | 2 million people | 21 million people |

The above table (3) shows the comparison between Gozaldoba Barrage (Teesta River, India) and Dalia Barrage (Teesta River, Bangladesh). The importance of Teesta's water for the Dalia's target area can be realized by this comparison.

**Reduced dry season flow in the Teesta River and its Effect on Socio-environmental conditions**

(This part deals with the socio-ecnomic characteristics and information on

* Manual(1993:3) Teesta Barrage Project, Bangladesh Water Development Board, Dalia, Rangpur

the basis of a recent survey (summary)

This study was carried out among the households who had lost land and properties due to Teesta River disasters who now have to live on the embankment or nearby villages of the Teesta River bank. Most (54%) of the respondents were found to be within the 40-50 years age range. The gender distribution of the study has been found 86.36 percent male and 13.63 percent female. A total of 101 households (Teesta River affected people were the respondents) were interviewed using a scheduled questionnaire adding an observation sheet. The respondents were selected by purposive sampling.

The average living year on an embankment (present address) after losing their original homes and land (past address) of the respondents was 9 years. Every year they face challenge of shifting their temporary houses due to shifting of the course of the river. The mean number of member per household was 5.57. In the occupational distribution of the respondents it was observed that, most of the respondents were day laborers (85 percent). Only 8 percent do agricultural work. The income distribution shows that the yearly income of the 85 percent of the respondents are Tk.12, 000(U$267), monthly is Tk. 1,000(U$22.22), and daily is Tk33.33 (0.74 U$) only approximately.

The 78.57 percent of the respondents were illiterate and among children 21.5 percent had been enrolled in Government and non-Govt. primary school. A very few number of respondents are educated in secondary school and colleges and they are about 7.2 percent. The study shows that 100 percent of the respondents have not any paternal land or resources and they live in the houses at present are their own. The study observed that bamboo; tin and straw were used to make the structure of the house.

Ninety one percent of the respondents were shown as landless and only 10 percent had some land and the average amount of land of that 10 percent is 1.45 acres. These landowners cultivate various crops. The average land use for paddy cultivation is 9 acres, jute 5 acres, wheat 3.6 acres, potato 2.2 acres sugarcane 0.45 acres mustard seeds 1 acre and others 1.35 acres. Average production of paddy in those land is rice 40.3 mound, jute 14.6 mound wheat 7.1 mound, potato 4.9 mound, sugarcane 10 and others 25 mounds.

Only 10 percent of the landowners have personal irrigation machine (shallow pump). Besides this they use rented irrigation such as power pump etc. They also use manure and chemical fertilizer for higher yield. The study shows that no land has been given as lease or mortgage to others. Only 3 percent took mortgage from other persons and the average amount of taking mortgage is 1 acre. The study shows that the traditional land transaction systems like Khaikhalashi (unconditional land using for a certain time) has been stopped.

The study points out that the respondents were not a member of any government (GO) or Non-government (NGO) development organization. Due to their floating nature and lack of ability to fulfill the conditions adopted by several NGO's (less than 0.50 acres of land should owned for security) the respondents are out of their target group for disbursing loans. The 100 percent of the respondents think that the most dreadful natural disaster is continuous flood and riverbank erosions. Only river erosion has changed their fortune to mass poverty and unthinkable misery.

The 73 percent of the respondents drink tube-well water, 29 percent drink

ground well water but most of the people use river water for bathing and dish washing. The 69 percent of the respondents have no latrine; they use bushes and bamboo gardens. The latrines in the area are made of bamboo and straw and there are no pucca infrastructures.
Bamboo and straw make the 90 percent houses. Eight percent have tin shade and only 2 percent have semi-pucca tin shade buildings. The 86 percent of the respondents thinks that the housing and sanitary condition of the area is not healthy and not suitable for human habitation.
Ninety five percent of the respondents opine that the embankment and barrage made by India over the border is the main cause for sudden flood and bank erosion. The same percent think that the Teesta Barrage (at Dalia-Doani point made by Bangladesh in1986) will bear no fruitful result if India does not obey the International water-sharing pact. They also think that the problem like sudden flood in April or in September is the result of opening the sluice gates to detract excessive water from the Indian portion.
The study focus that the total loses of land among the respondents is 252.04 acre. The money value of this land is 12336000Tk. (352457.14U$) and the money value of lost crops is U$6 million. The total affected people of 5 Thanas of the District is 2,53,460 and the average amount of lost land is 1,36,868 acre and the average money value of lost land is 6698951151Tk. (150 millionU$) in the last 10 years.
The 101 respondents think that the detract of the legal portion of the Teesta from the natural track to Bangladesh portion is illegal and it is of course a political problem and an inhuman aggression. They also think it is a negotiable problem between India and Bangladesh. The respondents think the claim for legal water sharing is legal and actual human rights. All the respondents urge to make metromin embankment on both banks of the Teesta River and build housing shelters.

**Detraction of excessive water in rainy season and chronic deluge in Bangladesh**
**(Effects of recent severe flooding)**

Crop Damages
Bangladesh have experienced natural calamities of different proportions during its history. But climatic events seem to be worsening in intensity, duration and frequency in recent years. The floods of 1998 in comparison with all previous floods in this country were of a very long duration. In 1998, three quarters of a million hectares of agricultural land were submerged and most of the autumn rice crops were ruined. Crop losses have been estimated at around $300 million. The country was airlifting supplies to remote areas after the virtual collapse of the country's road network, and with road communications severed in many parts of the country; prices of food were soaring.
Due to the flood, the season for planting of Aman *paddy was over without seeds having been being planted. This raises the spectre of future food deficit.
Farmers were not the only ones affected, as agricultural wage laborers had been unable to earn an income.
It is now certain that the country has become an aman wasteland. Whatever hopes there were for replanting and salvaging the Aman paddy

* Autumn planting paddy depending on natural rains.

crop has been dashed by the continuation of the floods. As the floodwaters engulfed the central areas of the country during the early flooding the higher regions of the north (in Rajshahi Division) remained the hope for HYV Aman. However much of this area has now also been inundated. This comes after the poor Aus* yield. In some areas, as much as 80% of the Aus have been damaged and the rest that survived are in poor condition.
Aus and Aman were lost more than 4 million tones; that was more than 50% of the expected production. As the floodwater was lingered, the possibility of sowing seeds (vegetables, mustard, wheat and potatoes, in the northern districts) in time was end. The soil contained abnormal moisture. Sowing was delayed by at least a month to mid December. That was again meant yield loss and increasing susceptibility to crop diseases.

Livestock

Besides the lost of human lives and crop damages, livestock had become a major victim of the floods. There was a severe crisis of both high ground and fodder; people were using water hyacinth, a poor substitute. Severe diarrhea attacks were occurred within few weeks. Prices of poultry feed has shot up by 20 to 40 percent and many poultry farmers were be wiped out.

Massive post flood agriculture rehabilitation was the order of the day. The country and its implanting agencies had not experienced anything like this in such an enormous scale. A concerted national effort was needed to put the rural economy back on its tottering feet.

Production of Rice:

Bangladesh grows rice in three seasons on 11 million hectares of land. The cropping pattern shows that the major rice crop is Aman (57%), followed by Aus (22%) and Boro (21%)* The general trend of cultivation is shown in the following table:

Table no-4, The general trend of paddy cultivation (in million ton)

| Rice Seasons | HYV | LV | Total | Percent |
|---|---|---|---|---|
| Boro(dry season) | 2.3 | Nil | 2.3 | 21 |
| Aus(dry season) | 0.9 | 1.5 | 2.4 | 22 |
| Aman | 1.5 | 4.8 | 6.3 | 57 |
| Total | 4.7 | 6.3 | 11.0 | 100 |
| Percent | 43 | 57 | 100 | |

If we take an optimistic average yield of HYV rice of 40 maunds per acre and local variety of 15 maunds per acre, the following table shows the production of rice in these seasons:

Table no-5, The general trend of paddy cultivation (in million ton)

| Rice Seasons | HYV | LV | Total | Percent |
|---|---|---|---|---|
| Boro(dry season) | 6.0 | Nil | 6.0 | 33 |
| Aus (dry season) | 2.3 | 1.4 | 3.7 | 20 |
| Aman | 4.0 | 4.7 | 8.7 | 47 |
| Total | 12.3 | 6.1 | 18.4 | 100 |

* Aus-Summer sowing paddy depending on natural rains.

* Boro-Summer planting High Yielding Variety (HYV) paddy by artificial irrigation system.

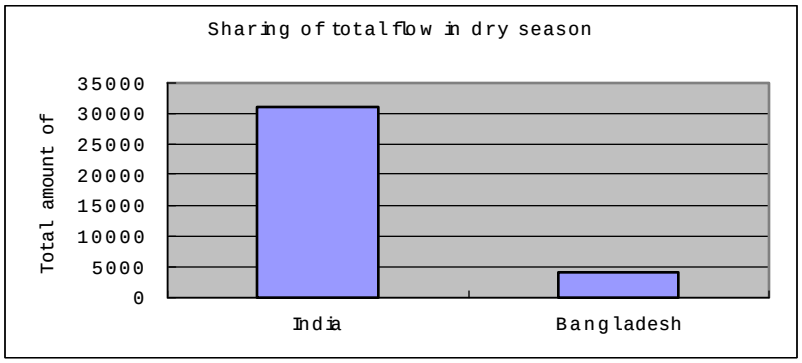
| | | | | |
|---|---|---|---|---|
| Percent | 67 | 33 | 100 | |

A 50 % loss of production of Aman and Aus would account for a loss of production of five million tons.

**Our proposal/Recommendations**

In the dry season the flow of the Teesta River goes down to a minimum of 850
cusecs.[**]

Fig.–06; Sharing of total flow of the Teesta River (in cusec)




But the average flow in the dry season is 3,000 to 4,000 cusecs, which is only 10-
15% of the total flow 35,000 cusecs inside India). Bangladesh needs minimum 8,000-10,000 cusecs to keep the barrage active in the dry season.[18]
The share can be described as in the figures below;

[*] 1 cusec=990 [2] metric tones of water per second

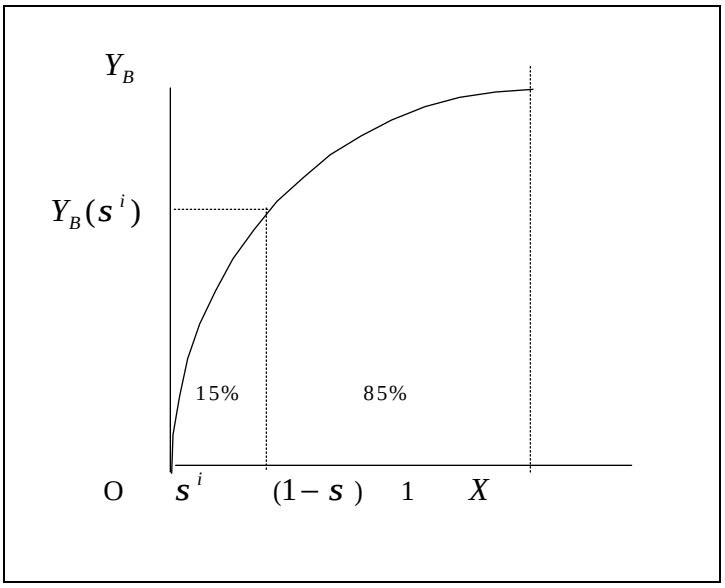



Fig.07; the initial stage of water sharing and
Production possibility curve in Bangladesh.

The objective function:

$$\max_{\{s\}} Y = Y_B(s) + Y_I(1-s)$$

$Y$ : Sum of the production of both countries

$Y_B(s)$ :Production in Bangladesh

$s^i$ : The rate of water sharing in Bangladesh

1-$s$ : the rate of water sharing in India

$X$ :Total quantity of water available in the Teesta River in dry season are 35000 cusecs and it in parameter

The figure 07 shows the initial stage of water sharing by Bangladesh and if Bangladesh gets much more amount of water, the production possibility curve
will be gradually higher.

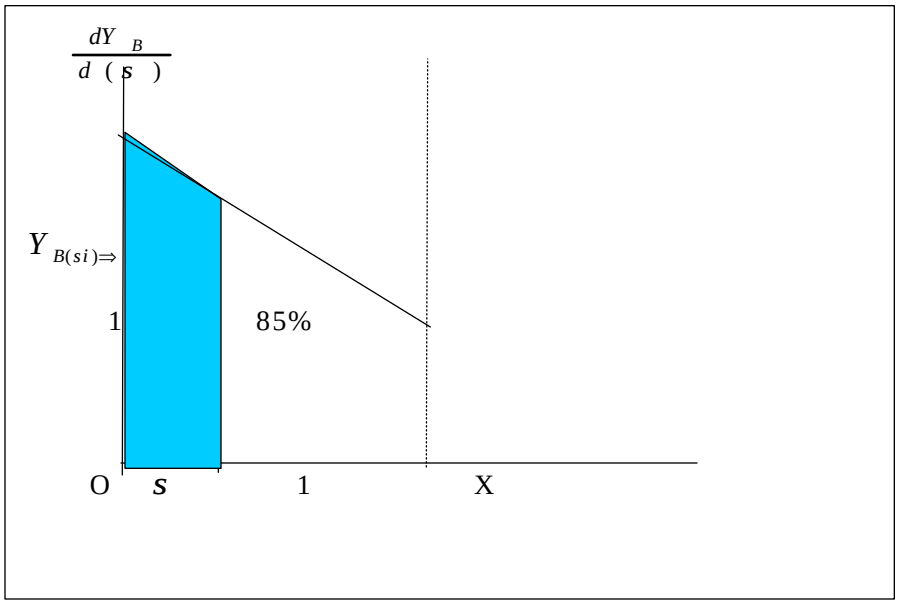
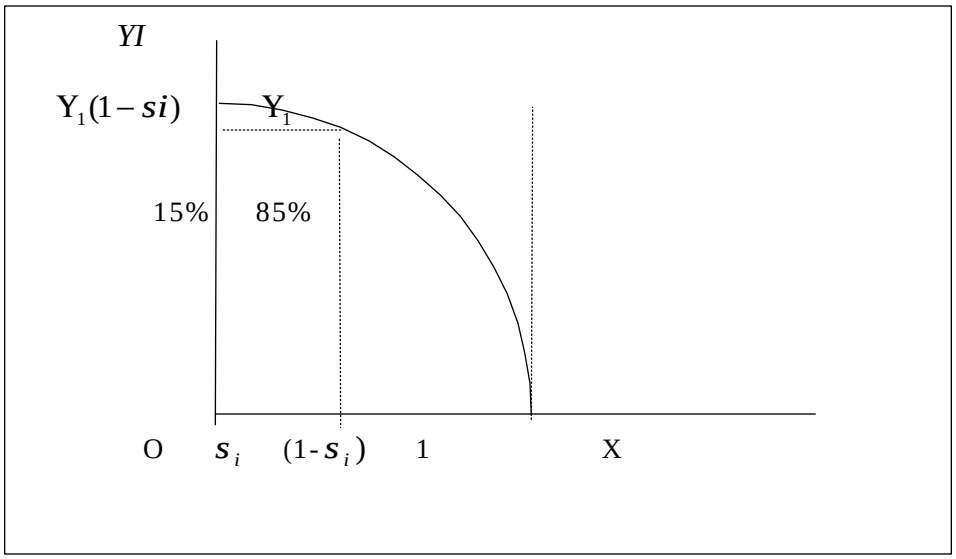


Fig.08; produced area at initial stage in Bangladesh

The figure 08 shows that, at the initial level of sharing water, Bangladesh can produce crops/services as much as in the $Y_{B(s\hat{i})}$ areas.

Figure-9

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The figure 09 shows, at the level of available water, the production in the Indian portion will be decreased as because the land of that area in the Indian Territory is less fertile than Bangladesh.* Though, use of fertilizer and technology can increase in agricultural production, but according to the theory of production; average production will be decreased. Considering the initial level of using water and fertilizer, we can assume that, the productivity of Bangladesh will be increased.

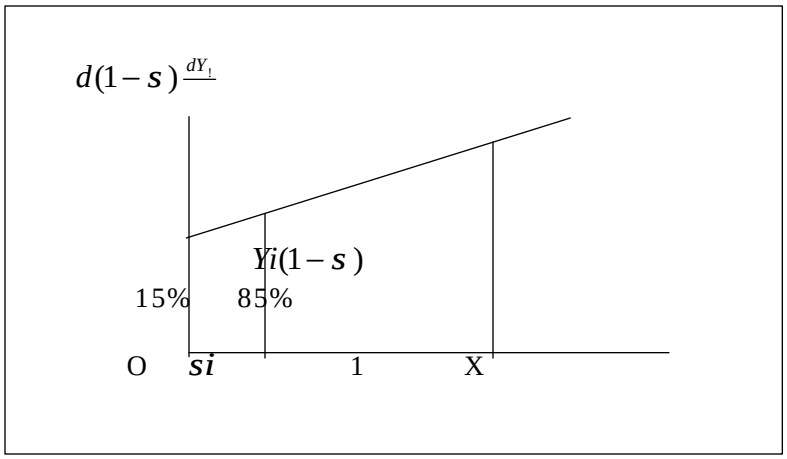
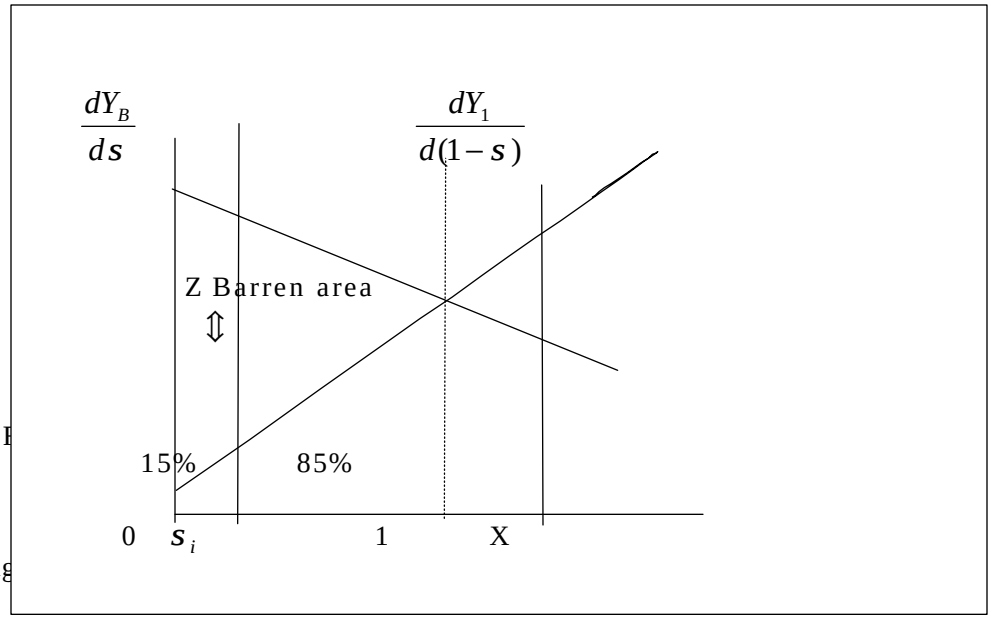



Fig.10 Initial level of using fertilizer and productivity of land of India & Bangladesh

At the initial level, India can produce crop/services as much as shown in the figure10.




Fig

The figure 11 shows that, the z area is barren due to lack of water in the dry season.

If we impose Fig.07 and Fig.09 on Fig 11, we can find out loss of production as much as in the Z (red) area. If we increase the rate of water in the Bangladesh portion (as the level of $s^*$), so we will not find out any loss, and we can get optimum quantity of production.

If the flow rise upto 30%, so that Bangladesh can irrigate crop fields of the target area of 14 districts If India shares more 15% percent of water (by sale) and if Bangladesh buy, then Bangladesh will be benefited as because the land of Bangladesh is more fertile than that of India.

That can be shown in the Fig.12 as;

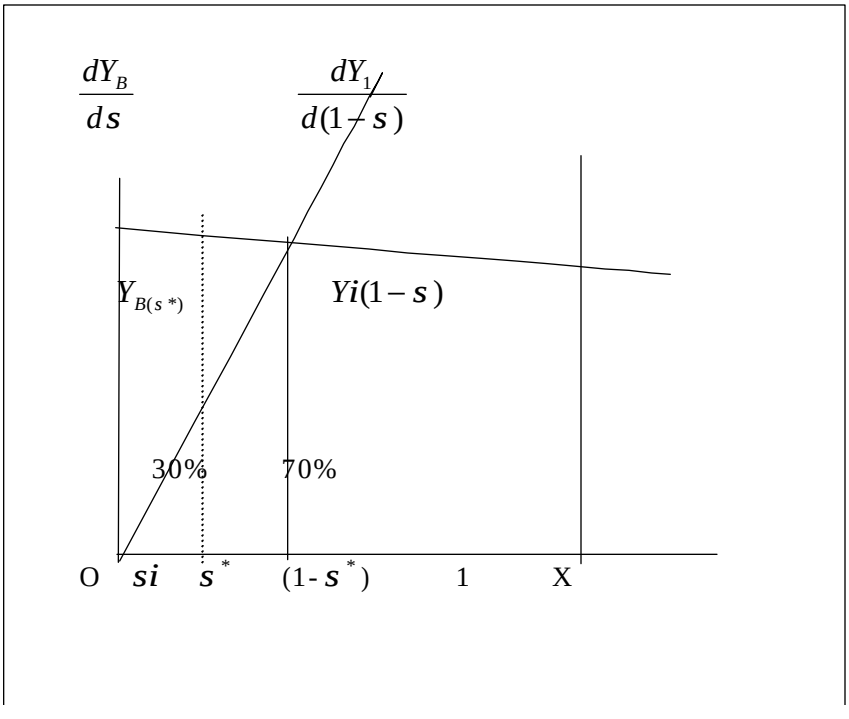


Fig.12; Optimization of water sharing between the two countries

Of course Bangladesh will agree to pay subsidies to the Indian authority for optimum sharing of water in the dry season.

2. Reasonable types of structural construction should be made on the both banks of the river. Marginal flood embankments to protect riverine villages and towns, roads and railways lead to the deterioration of the rivers by facilitating the deposition of a portion of silt contents within the riverbeds. Due to insufficiency of water and current flowing, riverbeds gradually rise and the process of siltation within the narrow river channels accelerate and the danger of breaches becomes more and more serious. As a result, the river overflows and ravages the area as a whole. So, there should be some regulation relating to any type of structural constructions on the bank of the river.

3. A very big dam for the preservation of excessive water of rainy season can be made but it is costly.

4. A program of "social forestry" can be undertaken and implemented to plant deep-rooted trees along the banks of the river in a planned way.

5. A rehabilitation program should be adopted for the people who already have been affected by the Teesta River disaster immediately.

6. Co-project or bilateral agricultural project can be adopted with the sharing of Teesta's water and then both of the countries will be benefited.

## Conclusion.

In a riverine country like Bangladesh, rivers and their variegated landscapes, obviously play a dominant role in its very geo-physical existence as well as in the economic development. So, further studies of this kind will be helpful to economists, planners and other decision-makers both of private and government arenas in tackling successfully many of the current inherent problems. Moreover we would like to state that, Bangladesh values its friendships with all nations, malice to none. Bangladesh sincerely urges to all nations and humanitarian agencies to utilize their resources to resolve this life-threatening situation. We hope, this study will make a fruitful and appropriate policy model and help in solving the problem.

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# Tables & Graphs:

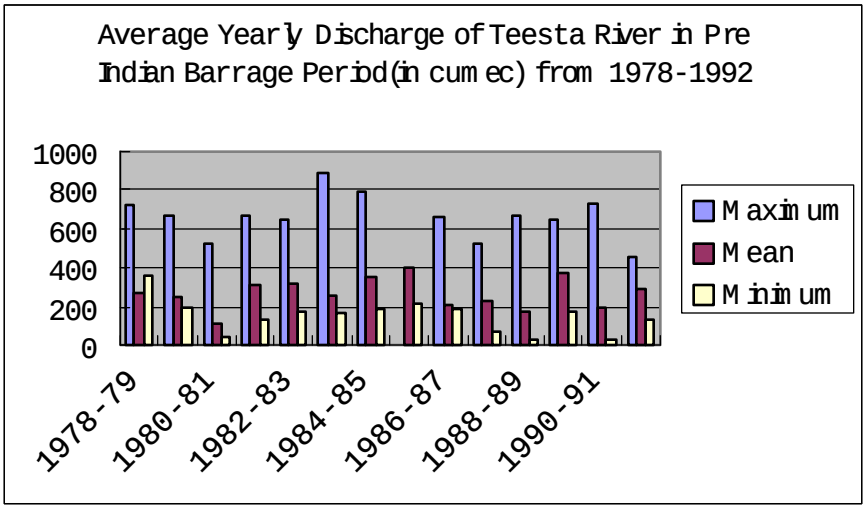
## Changes in Mean Monthly discharge of the Teesta River in the pre and post barrage operation

The following data show that, from the year 1978-79, there were no noticeable or drastic changes on the mean monthly discharge of the Teesta River

Extra table-1

| Changes in Mean yearly Discharge of Teesta River (1978-1993) | | | |
|---|---|---|---|
| Pre Gozaldoba period Water Discharge (in $m^3$/second) | | | |
| Year | Maximum | Mean | Minimum |
| 1978-79 | 721 | 541 | 361 |
| 1979-80 | 670 | 432 | 195 |
| 1980-81 | 522 | 330 | 137 |
| 198182 | 666 | 400 | 135 |
| 1982-83 | 652 | 415 | 177 |
| 1983-84 | 883 | 523 | 164 |

| | | | |
|---|---|---|---|
| 1984-85 | 795 | 488 | 182 |
| 1985-86 | 760 | 487 | 214 |
| 1986-87 | 660 | 425 | 190 |
| 1987-88 | 527 | 301 | 76 |
| 1988-89 | 667 | 397 | 127 |
| 1989-90 | 645 | 409 | 173 |
| 1990-91 | 729 | 427 | 125 |
| 1991-92 | 653 | 394 | 135 |




Extra figure –1

The above figure shows that, there were no noticeable changes on the water flow in the year 1978-1992.

## Post Gozaldoba Operation period

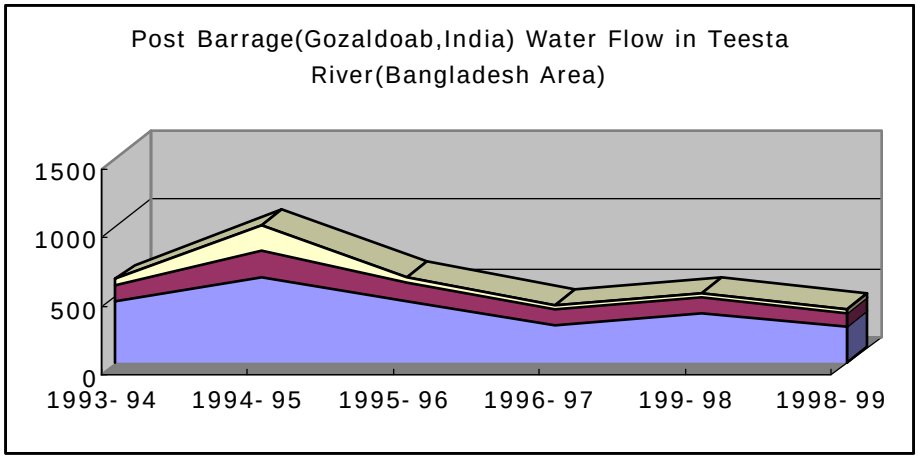
After the operation of the Gozaldoba Barrage (Indian side), the following data show, the radical changes on the minimum flow in dry season of the Teesta River as well as the Dalia Barrage point (Bangladesh side)

Extra table-2

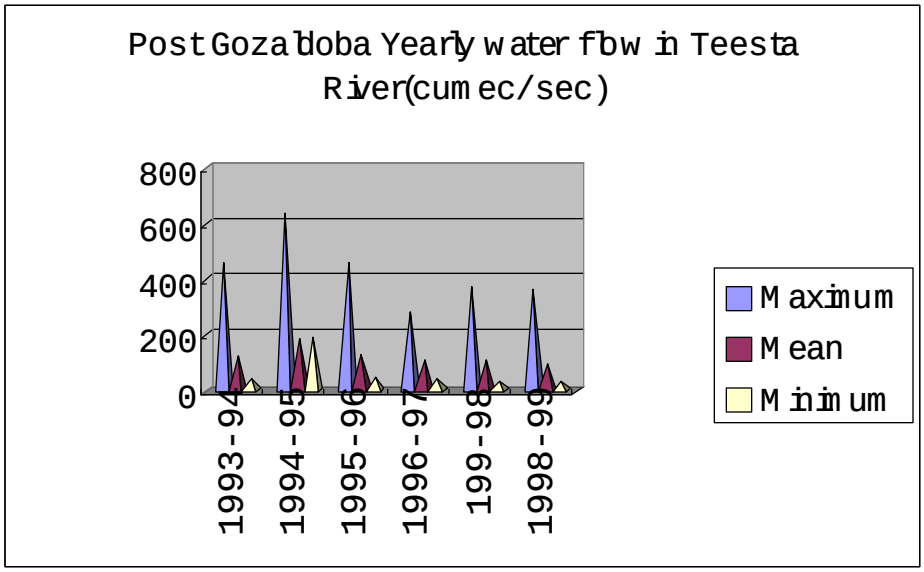
Yearly maximum, mean and minimum water level of Teesta River

| Post Gozaldoba period Water Discharge (in $m^3$/second) | | | |
|---|---|---|---|
| Year | Maximum | Mean | Minimum |
| 1993-94 | 453 | 296 | 138 |
| 1994-95 | 633 | 412 | 190 |
| 1995-96 | 459 | 252 | 44 |
| 1996-97 | 478 | 259 | 39 |
| 1997-98 | 672 | 353 | 34 |
| 1998-99 | 364 | 200 | 36 |

The above table shows the drastic changes in the minimum flow of dry season.




Extra figure-2




The Extra fig-3; After the operation of the Gozaldoba Barrage (Indian side), the above figure shows, the radical changes on the minimum flow in dry season.

**Difference between the Pre & Post Monthly Mean Discharge in the Dry Season of the Teesta River (Pre/19988-1993) & (Post/1994-1999)**

Extra table no-3

| Month | Mean(Pre )1989-1993 | Month | Mean(Post)1994-1998 |
|---|---|---|---|
| December | 130 | December | 98 |
| January | 127 | January | 90 |
| February | 132 | February | 71 |
| March | 111 | March | 46 |
| April | 120 | April | 32 |

The above table shows the reduced trend in average mean monthly discharge in the dry seasons.