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Climate Change Adaptation Strategies through Indigenous Knowledge System: Aspect on Agro-Crop Production in the Flood Prone Areas of Bangladesh

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Abstract

This study explores the climate change adaptation strategies for agro crop production and assesses the financial suitability through indigenous knowledge in flood prone areas of Bangladesh. However, for this purpose two types of experiments have conducted with selected eight agro crop species. Firstly, the seven treatments have been experimented in a Tub (an earthen pot). In this case, Tomato (Lycoperscion esculeatum) is more beneficial among these seven treatments and average benefit-cost ratio of this treatment was 3.54. Thereafter, the seven treatments also have been experimenting in *Tukri* (a bamboo basket). Likewise, Tomato (Lycoperscion esculeatum) is more beneficial in the second experiment and average benefit-cost ratio in this treatment is 3.52 because the soil and the cow dung mixture have been used as a potting medium. On the contrary, Long coriander (Eryngium foetidum) is more beneficial and average benefit-cost ratio in this treatment is 4.74 after using the soil and water hyacinth mixture as a potting medium. According to indigenous knowledge, these results could be developed from different climate change adaptation strategies in farming system for production of common agro crops as well as their financial suitability by the flood affected people of Bangladesh to harness the effect of climate change.

Keywords: Local knowledge, natural hazard, financial suitability, strategy's development, farming system, developing country

Introduction

Climate change is one of the most talked of the world-wide topics now-a-days. It is now widely recognized as the most significant environmental issue that mankind badly faces. Changes in climate have been commonly observed in many regions of the globe. It is revealed that changes in temperature and rainfall resulting increases in frequency and intensity of flood, cyclones and drought events have affected to the livelihoods, culture and health of people on the earth (IPCC, 2007; Ogata and Sen, 2003; Barnett, 2003). These cases can threaten the sustainability of development processes and poverty reduction (Few *et al.*, 2006). It is predicted that billions of people in developing countries will face shortages of water, food and greater risks to health and life. It is required to enable developing countries to adapt to the effects of climate change (UNFCCC, 2007).

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Bangladesh is one of the disaster-prone developing countries. Almost every year, the country experiences disasters of one sort or another such as tropical cyclones, storm surges, coastal erosion, monsoon wind, evaporation for monsoon rainfall, floods and droughts (Ali, 1999) causing heavy loss of life and property and threatening the development activities. In future, Bangladesh is likely to be one of the most vulnerable areas of the world. An average temperature and annual mean rainfall have registered an increasing trend. The precipitation decline and droughts have resulted in the drying up of wetlands and severe degradation of ecosystems (IPCC, 2007). Almost every sector of Bangladesh is probably to be affected by climate change. However, the people of this country have fewer resources to adapt socially, technologically and financially. Bangladesh is a country where agriculture is the largest sector of the economy. Agriculture in Bangladesh has been already under pressure from increasing demands for food and the parallel problems of depletion of agricultural land. The impact of climate variability and change on agricultural production is a global concern. Adaptation to climate change is one of the approaches considered likely to reduce the impacts of long-term changes in climate variables. Adaptation is a process by which strategies to moderate and cope with the consequences of climate change impact variability, can be enhanced, developed and implemented (UNDP, 2004). Evidently, many developing countries have already conformed to current climatic events at national, provincial, state, territory and local levels in the short-term, medium-term and long-term time frames.

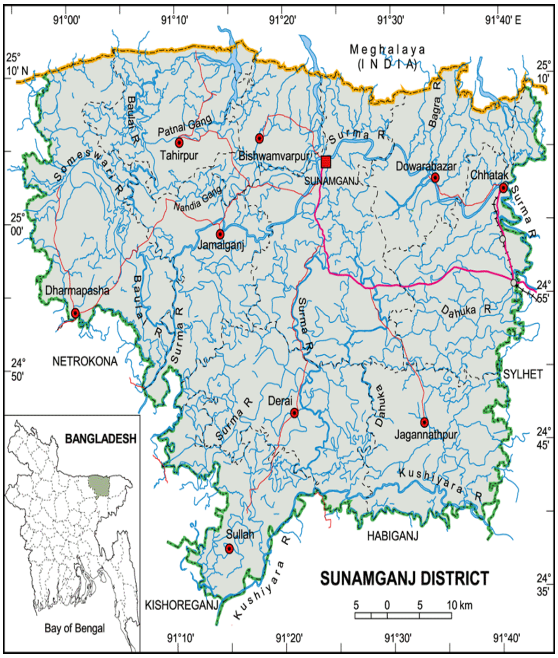
Indigenous knowledge has been defined as institutionalized local knowledge that has been built upon and verbally passed on from one generation to the other (Osunade, 1994; Warren, 1992). It is the basis for local-level decision-making in many rural communities. Indigenous knowledge has value not only for the culture in which it evolves, but also for scientists and planners striving to improve conditions in rural localities (Mundy and Compton, 1991). The knowledge set is determined by the previous generations, observations and experiment and provides an inherent connection to one's surroundings and environment. Consequently, indigenous knowledge is not transferable but provides relationships that connect people directly with environments (Woodley, 1991).

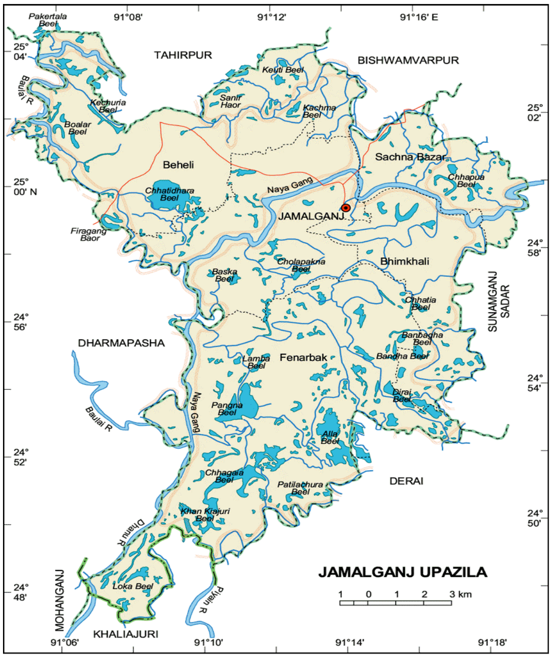
These findings concentrate on the development of some low cost climate change adaptation strategies for agro crop production in the flood prone areas of Bangladesh, and examine their low cost financial suitability. These developed adaptation strategies may facilitate the rural poor farmer to face the challenge of climate change in near future.

Material and methods

Study area

The experiments were carried out in the *Jamalgonj* Upajila (Sub-district) which is situated under the district of *Sunamgonj* area of Bangladesh. This *Jamalgonj* Upazila is located in between 24°50´ and 25°04´ northern latitudes and in between 91°05´ and 91°19´ east longitudes. It is bounded by *Tahirpur* and *Bishwambarpur* upazilas on the north, *Khaliajuri* and *Derai* upazilas on the south, *Sunamganj Sadar* upazila on the east, *Mohanganj* and *Dharmapasha* upazilas on the west. (Banglapedia, 2012). The climate is humid subtropical with a predominantly hot and humid summer and a relatively cool winter. Average annual rainfall of *Sunamgonj* district is between (4000-5500) mm and mean annual temperature is (24.5-26.0)°C (Hossain, 1990). However, the total area of *Jamalgoonj* is 338.78 sq km, and crossed by the great river *Surma*. Others river is *Nawa Gang*, *Baulai* and *Dhanu*. A lot of wetland including *Pakna Haor*, *Halir Haor*, *Chanuar Haor* and *Dakuar Haor* and the *Beel of Patilachura*, *Pangna*, *Lamba*, *Baska*, *Chhatidhara* and *Kachma* are noted. The purposive sampling areas remain submerged for the six months in every year (Banglapedia, 2012) (Figure 1).





Map 1: Location of the study area

Map 2: Location of the study area

(**Map credit:** Banglapedia, 2012**)**

Data sources and sampling technique

The study areas were selected purposefully as there are farming systems. Also farmers were selected randomly with the sampling of the three Unions, namely as *Jamalgonj Sadar Union*, *Bhimkhali Union* and *Beheli Union*. A semi-structured questionnaire was prepared for interviewing farmers by direct observation of their farming system. Unit price (/Kg) was collected through market survey by random sampling over one week of each replicate treatment yield production variable.

Crop selection

The potential agro crops were chosen for the study through market survey. The selected agro crops were preferred both by farmers and consumer in their daily food items. And these selected agro crops are Bean (*Lablab purpureus*), Tomato (*Lycoperscion esculeatum*), Cowpea (*Vigna sinensis)* Long coriander (*Eryngium foetidum*), Bottle gourd *(Lageneria siceraria)*, Kangkong (*Ipomoea reptans*), Spinach *(Spinacea Oleracea).*

Experimental pattern

There are carried out two different types of experiments in this study and they are as follows–

Experiment-A

A randomized complete block design with five replicates was adopted for each treatment in this study. There were altogether 35 tubs involving treatments combine with 7 various hybrid species. The experiment has the following treatments- T_A: Bean+*Tub;* T_B: Cowpea + *Tub;* T_C: Tomato + *Tub;* $T_{D:}$ Kangkong + *Tub;* T_E: Spinach + *Tub;* T_F: Long coriander + *Tub;* T_G: Bottle gourd + *Tub.*

Experiment-B

The beneficial impact of cow dung and water hyacinths for improving the growth of agro crop was examined in this experiment. Randomized complete block design with five replicates of each treatment was adopted. There were altogether 70 *tukri* involving treatments combined with seven various species whereby 35 *tukri (Bamboo basketry)* involving treatment matching with cow dung and soil glutted potting media and another 35 *tukri* involving treatment design with water hyacinth and soil belonging same species. The experiment has the following treatments- T_A: Bean +*Tukri;* T_B: Cowpea + *Tukri;* T_C: Tomato + *Tukri;* T_D: Kangkong + *Tukri;* T_E: Spinach + *Tukri;* T_F: Long coriander + *Tukri;* T_G: Bottle gourd + *Tukri*.

Benefit-cost ratio (BCR)

Benefit-cost ratio (BCR) is used for decision making about the establishing farming techniques. The benefit-cost ratio is calculated by total benefit divided total cost. And, net income *(NI)* is calculated by the total income (TI) minus total cost (TC).

Results and discussion

Results

In this study, different types of adaptation strategies for agro-crop production are examined through an experimental treatment for flood prone areas of Bangladesh. They can be used all the year round as for summer and winter crops and can supply enough agro crops to be eaten and sold in climate change adverse condition.

Experiment A

Cost benefit analysis

Cost benefit analysis for thirty five tubs of seven treatments were measured here. Total benefit is 899.63Tk. (BDT) (10.81USD)[2]. If the farmers do not destructed the tub until broken and keep it for the next year application for better production, he/she will derive more benefit initially only 1249.63Tk. If the farmers contribute his/her own labor in this farming system, he/she will be gain net benefit 1179.63 Tk. Among the seven treatment T_C is more beneficial. The average B/C ratio of this treatment is 3.54 followed by T_G(3.22), T_F(2.14) T_B(1.41), T_E(1.34) T_A(1.16) and T_D(1.04) The lowest B/C ratio was found in the treatment T_D (1.04) (Table 1).

[2] 01 USD = 83.1910 BDT as of 28th April, 2012

Table 1: Cost benefits analysis (Tub)

Treatment	R	Expenditure (Tk.)							Revenue (Tk.)				**Benefit cost ratio
		Labor	Seed	Top	Cow dung	Pesticide	Transports	Total cost	Production(Kg)	*Unite Price/(Kg)	Income	*Net income	
T_A	T_{A1}	8	2.00	10	1.20	0.50	0.8	22.50	0.50	26.00	13.00	-9.5	0.58
	T_{A2}	8	2.00	10	1.20	0.50	0.8	22.50	1.50	26.00	39.00	16.5	1.73
	T_{A3}	8	2.00	10	1.20	0.50	0.8	22.50	1.00	26.00	26.00	3.5	1.16
	T_{A4}	8	2.00	10	1.20	0.50	0.8	22.50	0.50	26.00	13.00	-9.5	0.58
	T_{A5}	8	2.00	10	1.20	0.50	0.8	22.50	1.50	26.00	39.00	16.5	1.73
Average		**8**	**2.00**	**10**	**1.20**	**0.50**	**0.8**	**22.50**	**1.00**	**26.00**	**26.00**	**3.5**	**1.16**
T_B	T_{B1}	8	1.20	10	1.20	0.30	0.8	21.50	1.00	28.42	28.42	6.92	1.32
	T_{B2}	8	1.20	10	1.20	0.30	0.8	21.50	1.50	28.42	42.63	21.13	1.98
	T_{B3}	8	1.20	10	1.20	0.30	0.8	21.50	2.50	28.42	71.05	49.55	3.30
	T_{B4}	8	1.20	10	1.20	0.30	0.8	21.50	2.00	28.42	56.84	35.34	2.64
	T_{B5}	8	1.20	10	1.20	0.30	0.8	21.50	0.50	28.42	14.21	-7.29	0.66
Average		**8**	**1.20**	**10**	**1.20**	**0.30**	**0.8**	**21.50**	**1.07**	**28.42**	**30.41**	**8.91**	**1.41**
T_C	T_{C1}	8	1.20	10	1.20	0.40	0.8	21.60	2.50	45.00	112.50	90.9	5.21
	T_{C2}	8	1.20	10	1.20	0.40	0.8	21.60	1.00	45.00	45.00	23.4	2.08
	T_{C3}	8	1.20	10	1.20	0.40	0.8	21.60	2.50	45.00	112.50	90.9	5.21
	T_{C4}	8	1.20	10	1.20	0.40	0.8	21.60	0.50	45.00	22.50	0.9	1.04
	T_{C5}	8	1.20	10	1.20	0.40	0.8	21.60	2.00	45.00	90.00	68.4	4.17
Average		**8**	**1.20**	**10**	**1.20**	**0.40**	**0.8**	**21.60**	**1.70**	**45.00**	**76.50**	**54.9**	**3.54**
T_D	T_{D1}	8	1.50	10	1.20	0.00	0.8	21.50	0.50	18.57	9.29	-12.22	0.43
	T_{D2}	8	1.50	10	1.20	0.00	0.8	21.50	1.50	18.57	27.86	6.36	1.30
	T_{D3}	8	1.50	10	1.20	0.00	0.8	21.50	0.50	18.57	9.29	-12.22	0.43
	T_{D5}	8	1.50	10	1.20	0.00	0.8	21.50	1.00	18.57	18.57	-2.93	0.86
	T_{D5}	8	1.50	10	1.20	0.00	0.8	21.50	2.50	18.57	46.43	24.93	2.16
Average		**8**	**1.50**	**10**	**1.20**	**0.00**	**0.8**	**21.50**	**1.20**	**18.57**	**22.28**	**0.78**	**1.04**
T_E	T_{E1}	8	1.00	10	1.20	0.00	0.8	21.00	1.00	31.22	31.22	10.22	1.49
	T_{E2}	8	1.00	10	1.20	0.00	0.8	21.00	1.50	31.22	46.83	25.83	2.23
	T_{E3}	8	1.00	10	1.20	0.00	0.8	21.00	0.50	31.22	15.61	-5.39	0.74
	T_{E4}	8	1.00	10	1.20	0.00	0.8	21.00	1.00	31.22	31.22	10.22	1.49
	T_{E5}	8	1.00	10	1.20	0.00	0.8	21.00	0.50	31.22	15.61	-5.39	0.74
Average		**8**	**1.00**	**10**	**1.20**	**0.00**	**0.8**	**21.00**	**0.90**	**31.22**	**28.10**	**7.10**	**1.34**
T_F	T_{F1}	8	4.00	10	1.20	0.00	0.8	24.00	0.30	160.72	48.22	24.22	2.01
	T_{F2}	8	4.00	10	1.20	0.00	0.8	24.00	0.20	160.72	32.14	8.14	1.34
	T_{F3}	8	4.00	10	1.20	0.00	0.8	24.00	0.40	160.72	64.29	40.29	2.68
	T_{F4}	8	4.00	10	1.20	0.00	0.8	24.00	0.50	160.72	80.36	56.36	3.35
	T_{F5}	8	4.00	10	1.20	0.00	0.8	24.00	0.20	160.72	32.14	8.14	1.34

Average		**8**	**4.00**	**10**	**1.20**	**0.00**	**0.8**	**24.00**	**0.32**	**160.72**	**51.43**	**27.43**	**2.14**
	T_{G1}	8	1.50	10	1.20	0.00	0.8	21.50	4 pieces	28.86/ piece	115.44	93.94	5.37
	T_{G2}	8	1.50	10	1.20	0.00	0.8	21.50	2 pieces	28.86/ piece	57.72	36.22	2.68
	T_{G3}	8	1.50	10	1.20	0.00	0.8	21.50	1 pieces	28.86/ piece	115.44	93.94	5.37
T_G	T_{G4}	8	1.50	10	1.20	0.00	0.8	21.50	3 pieces	28.86/ piece	86.58	65.08	4.03
	T_{G5}	8	1.50	10	1.20	0.00	0.8	21.50	2 pieces	28.86/ piece	57.72	36.22	2.68
Average		**8**	**1.50**	**10**	**1.20**	**0.00**	**0.8**	**21.50**	**2.4 pieces**	**28.86/ piece**	**69.26**	**47.76**	**3.22**

Notes: *R=Replicates, T_A=Bean, T_B=Cowpea T_C=Tomato, T_D=Kangkong, T_E= Spinach; T_F= Long coriander*; *T_G= Bottle gourd* * Net income is estimated as the total income minus total cost. **Benefit- cost ratio is estimated as income divided by total cost. *Unit price (/Kg) was collected through market survey by random sampling over one week of each replicate treatment yield production variable. Each value under expenditure and revenue represent the seasonally expenditure and revenue except tub cost over a rotation length of 6 months. This experiment includes an allowance for unpaid labor of the experiment treatment estimated at the present wage rate (wage rate/ day; male Tk.200) and every day one labor has prepared 25 *tub*.

Modification of adaptation strategies

Dais/stage adaptation

The stage preparation technique may be a new farming system in flood prone areas of Bangladesh. An effort of practicing stage preparation has been reported here. Tub beds were shifted on the bamboo stage made on the pond. Stage established (a platform for keeping plants tub bed) by_pieces of bamboo. In the stage establishment, at first six pieces of bamboo were driven into the soil under the water of the pond at a proper distance mainly 5-6 ft away from each other. Then two bamboo pieces were parallels tied by plastic ropes for strengthen of the stage then again another two bamboo pieces were parallel tied by plastic ropes. Similarly, bamboo sticks were crossly arranged to prepare the platform for putting tubes. Tubs were put on the stage for cultivation of crops. Finally, crops from the stage were harvested manually or with knives (Figure-2).

Fig-a

Fig-b

Figure 2: Clockwise stage preparation and their adaptation technique (Fig-a: Bamboo sticks were crossly arranged and attached by plastic ropes; Fig-b: Bamboo stage made on the pond and adapting over-view with crop tub gathers on the stage)

Experiment-B

The techniques of two experiments were altogether combined with seven various species - the first experiment involving treatment matching with cow dung and soil glutted potting media and second involving treatment design with water hyacinth and soil belonging same species.

Cost benefit analysis

Cost benefit analyses for thirty five *tukri* were measured here. Total benefit 1161.03 Tk. (BDT) (13.96 USD) [1]. If the farmers do not destructed the *tukri* until decompose and keep it for the next year production for better yield, he/she will gain benefit initially only 1686.03 Tk. (BDT) (20.27 USD)[1]. If the farmers contribute his/her own labor in this farming system, he/she will be gain net benefit 1511.03 Tk. (BDT) (18.16 USD)[1]. Among the seven treatments T_C is more beneficial. The average B/C ratio of this treatment is 3.52 followed by T_F (3.36), T_G (2.58), T_B (2.01), T_A (1.94) T_D (1.43) and T_E (0.95). The lowest B/C ratio was found in the treatment T_E (0.95) (Table 2). Controversy, second experiment had measured total benefit 1818.36 Tk. (BDT) (21.86 USD)[1]. If the farmers do not destructed the *tukri* bed until decompose and keep it for the next year application for better production, he/she will gain benefit initially only 2343.36 Tk. (BDT) (28.17 USD)[1]. If the farmers contribute his/her own labor in this farming system, he/she will be gain net benefit 2168.36 Tk. (BDT) (26.06 USD)[1]. Among the seven treatments T_F is more beneficial. The average B/C ratio of this treatment is 4.74 followed by T_G (3.46), T_B (3.26), T_C (2.74), T_A (2.69), T_E (1.65), T_D (1.24) and the lowest B/C ratio was found in the treatment T_D (1.24) (Table 3).

Table 2: Cost benefits analysis (*Tukri*; Soil + Cow dung)

		Expenditure (Tk.)							Revenue (Tk.)				
Treatment	**R**	Labor	Seed	*Tukri*	Cow dung	Pesticide	Transports	Total Cost	Production(Kg)	Unite Price/(Kg)	Income	*Net income	**Benefit cost ratio**
	T_{A1}	10	2.00	15	3.50	0.50	2.50	33.50	2.50	26.00	65.00	31.5	1.94
	T_{A2}	10	2.00	15	3.50	0.50	2.50	33.50	3.00	26.00	78.00	44.5	2.33
T_A	T_{A3}	10	2.00	15	3.50	0.50	2.50	33.50	3.50	26.00	91.00	57.5	2.72
	T_{A4}	10	2.00	15	3.50	0.50	2.50	33.50	1.50	26.00	39.00	5.5	1.16
	T_{A5}	10	2.00	15	3.50	0.50	2.50	33.50	2.00	26.00	52.00	18.5	1.55
Average		**10**	**2.00**	**15**	**3.50**	**0.50**	**2.50**	**33.50**	**2.50**	**26.00**	**65.00**	**31.5**	**1.94**
	T_{B1}	10	1.20	15	3.50	0.30	2.50	32.50	2.50	28.42	71.05	38.55	2.19
	T_{B2}	10	1.20	15	3.50	0.30	2.50	32.50	3.50	28.42	99.47	66.97	3.06
T_B	T_{B3}	10	1.20	15	3.50	0.30	2.50	32.50	1.50	28.42	42.63	10.13	1.31
	T_{B4}	10	1.20	15	3.50	0.30	2.50	32.50	3.00	28.42	85.26	52.76	2.62
	T_{B5}	10	1.20	15	3.50	0.30	2.50	32.50	1.00	28.42	28.42	-4.08	0.87
Average		**10**	**1.20**	**15**	**3.50**	**0.30**	**2.50**	**32.50**	**2.30**	**28.42**	**65.37**	**32.87**	**2.01**
	T_{C1}	10	1.00	15	3.50	0.00	2.50	32.00	2.00	45.00	90.00	58	2.81
	T_{C2}	10	1.00	15	3.50	0.00	2.50	32.00	1.50	45.00	67.50	35.5	2.11
T_C	T_{C3}	10	1.00	15	3.50	0.00	2.50	32.00	2.00	45.00	90.00	58	2.81
	T_{C4}	10	1.00	15	3.50	0.00	2.50	32.00	1.00	45.00	45.00	13	1.41
	T_{C5}	10	1.00	15	3.50	0.00	2.50	32.00	1.00	45.00	45.00	13	1.41
Average		**10**	**1.50**	**15**	**3.50**	**0.00**	**2.50**	**32.00**	**2.50**	**45.00**	**112.50**	**80.5**	**3.52**
	T_{D1}	10	1.50	15	3.50	0.00	2.50	32.50	2.00	18.57	37.14	4.64	1.14
T_D	T_{D2}	10	1.50	15	3.50	0.00	2.50	32.50	1.00	18.57	18.57	-13.93	0.57
	T_{D3}	10	1.50	15	3.50	0.00	2.50	32.50	1.50	18.57	27.86	-4.65	0.86

	T_{D4}	10	1.50	15	3.50	0.00	2.50	32.50	2.00	18.57	37.14	4.64	1.14
	T_{D5}	10	1.50	15	3.50	0.00	2.50	32.50	1.80	18.57	33.43	0.93	1.03
Average		**10**	**1.50**	**15**	**3.50**	**0.00**	**2.50**	**32.50**	**2.50**	**18.57**	**46.43**	**13.93**	**1.43**
	T_{E1}	10	2.00	15	3.50	0.00	2.50	33.00	1.00	31.22	31.22	-1.78	0.95
	T_{E2}	10	2.00	15	3.50	0.00	2.50	33.00	1.00	31.22	31.22	-1.78	0.95
T_E	T_{E3}	10	2.00	15	3.50	0.00	2.50	33.00	1.50	31.22	46.83	13.83	1.42
	T_{E4}	10	2.00	15	3.50	0.00	2.50	33.00	1.00	31.22	31.22	-1.78	0.95
	T_{E5}	10	2.00	15	3.50	0.00	2.50	33.00	0.50	31.22	15.61	-17.39	0.47
Average		**10**	**2.00**	**15**	**3.50**	**0.00**	**2.50**	**33.00**	**1.00**	**31.22**	**31.22**	**-1.78**	**0.95**
	T_{F1}	10	4.00	15	3.50	0.00	2.50	35.00	0.80	160.72	117.71	82.71	3.36
	T_{F2}	10	4.00	15	3.50	0.00	2.50	35.00	0.50	160.72	73.57	38.57	2.10
T_F	T_{F3}	10	4.00	15	3.50	0.00	2.50	35.00	1.10	160.72	161.85	126.85	4.62
	T_{F4}	10	4.00	15	3.50	0.00	2.50	35.00	0.40	160.72	58.86	23.86	1.68
	T_{F5}	10	4.00	15	3.50	0.00	2.50	35.00	1.20	160.72	176.57	141.57	5.04
Average		**10**	**4.00**	**15**	**3.50**	**0.00**	**2.50**	**35.00**	**0.80**	**160.72**	**117.71**	**82.71**	**3.36**
	T_{G1}	10	2.50	15	3.50	0.00	2.50	33.50	4 pieces	28.86/ piece	115.44	81.94	3.45
	T_{G2}	10	2.50	15	3.50	0.00	2.50	33.50	2 pieces	28.86/ piece	57.72	24.22	1.72
	T_{G3}	10	2.50	15	3.50	0.00	2.50	33.50	4 pieces	28.86/ piece	115.44	81.94	3.45
*T_G	T_{G4}	10	2.50	15	3.50	0.00	2.50	33.50	3 pieces	28.86/ piece	86.58	53.08	2.58
	T_{G5}	10	2.50	15	3.50	0.00	2.50	33.50	2 pieces	28.86/ piece	57.72	24.22	1.72
		10	**2.50**	**15**	**3.50**	**0.00**	**2.50**	**33.50**	**3 pieces**	**28.86/ piece**	**86.58**	**53.08**	**2.58**

Notes: *R=Replicates, T_A=Bean, T_B=Cowpea, T_C=Tomato, T_D=Kangkong, T_E= Spinach, T_F= Long coriander, *T_G=Bottle gourd,* In case of *T_G(Bottle gourd)* was sold unit of price per piece. * Net income is estimated as the total income minus total cost. **Benefit- cost ratio is estimated as income divided by total cost. Each value under expenditure and revenue represent the seasonally expenditure and revenue except *tukri* cost over a rotation length of 6 months. This experiment includes an allowance for unpaid labor of the experiment treatment estimated at the present wage rate (wage rate/ day; male Tk.200) and every day one labor has prepared 20 *tukri*.

Table 3: Cost benefits analysis (*Tukri*; Soil + Water hyacinth)

Treatment	R	Expenditure (Tk.)						Revenue (Tk.)				
		Labor	Seed	*Tukri*	Pesticide	Transports	Total Cost	Production(Kg)	Unite Price/(Kg)	Income	*Net income	**Benefit cost ratio**
T_A	T_{A1}	10	2.00	15	0.60	1.43	29.03	4.50	26.00	117.00	87.97	4.03
	T_{A2}	10	2.00	15	0.60	1.43	29.03	3.00	26.00	78.00	48.97	2.69
	T_{A3}	10	2.00	15	0.60	1.43	29.03	3.50	26.00	91.00	61.97	3.13
	T_{A4}	10	2.00	15	0.60	1.43	29.03	1.50	26.00	39.00	9.97	1.34
	T_{A5}	10	2.00	15	0.60	1.43	29.03	2.50	26.00	65.00	35.97	2.24
Average		**10**	**2.00**	**15**	**0.60**	**1.43**	**29.03**	**3.00**	**26.00**	**78.00**	**48.97**	**2.69**
T_B	T_{B1}	10	1.20	15	0.30	1.43	27.93	2.50	28.42	71.05	43.12	2.54
	T_{B2}	10	1.20	15	0.30	1.43	27.93	3.50	28.42	99.47	71.54	3.56
	T_{B3}	10	1.20	15	0.30	1.43	27.93	4.50	28.42	127.89	99.96	4.58
	T_{B4}	10	1.20	15	0.30	1.43	27.93	3.00	28.42	85.26	57.33	3.05
	T_{B5}	10	1.20	15	0.30	1.43	27.93	2.50	28.42	71.05	43.12	2.54
Average		**10**	**1.20**	**15**	**0.30**	**1.43**	**27.93**	**3.20**	**28.42**	**90.94**	**63.01**	**3.26**
T_C	T_{C1}	10	1.00	15	0.50	1.43	27.93	2.50	45.00	112.50	84.57	4.03
	T_{C2}	10	1.00	15	0.50	1.43	27.93	1.50	45.00	67.50	39.57	2.42
	T_{C3}	10	1.00	15	0.50	1.43	27.93	2.00	45.00	90.00	62.07	3.22
	T_{C4}	10	1.00	15	0.50	1.43	27.93	1.50	45.00	67.50	39.57	2.42
	T_{C5}	10	1.00	15	0.50	1.43	27.93	1.00	45.00	45.00	17.07	1.61
Average		**10**	**1.00**	**15**	**0.50**	**1.43**	**27.93**	**1.70**	**45.00**	**76.50**	**48.57**	**2.74**
T_D	T_{D1}	10	1.40	15	0.00	1.43	27.83	1.70	18.57	31.57	3.74	1.13
	T_{D2}	10	1.40	15	0.00	1.43	27.83	1.50	18.57	27.86	0.03	1.00
	T_{D3}	10	1.40	15	0.00	1.43	27.83	1.00	18.57	18.57	-9.26	0.67
	T_{D4}	10	1.40	15	0.00	1.43	27.83	2.80	18.57	52.00	24.17	1.87
	T_{D5}	10	1.40	15	0.00	1.43	27.83	2.30	18.57	42.71	14.88	1.53

Average		**10**	**1.40**	**15**	**0.00**	**1.43**	**27.83**	**1.86**	**18.57**	**34.54**	**6.71**	**1.24**
T_E	T_{E1}	10	2.00	15	0.00	1.43	28.43	1.50	31.22	46.83	18.40	1.65
	T_{E2}	10	2.00	15	0.00	1.43	28.43	1.20	31.22	37.46	9.03	1.32
	T_{E3}	10	2.00	15	0.00	1.43	28.43	1.50	31.22	46.83	18.40	1.65
	T_{E4}	10	2.00	15	0.00	1.43	28.43	1.60	31.22	49.95	21.52	1.76
	T_{E5}	10	2.00	15	0.00	1.43	28.43	0.50	31.22	15.61	-12.82	0.55
Average		**10**	**2.00**	**15**	**0.00**	**1.43**	**28.43**	**1.50**	**31.22**	**46.83**	**18.40**	**1.65**
T_F	T_{F1}	10	3.40	15	0.00	1.43	29.83	0.50	160.72	80.36	50.53	2.69
	T_{F2}	10	3.40	15	0.00	1.43	29.83	1.20	160.72	192.86	163.03	6.47
	T_{F3}	10	3.40	15	0.00	1.43	29.83	0.30	160.72	48.22	18.39	1.62
	T_{F4}	10	3.40	15	0.00	1.43	29.83	1.40	160.72	225.01	195.18	7.54
	T_{F5}	10	3.40	15	0.00	1.43	29.83	1.00	160.72	160.72	130.89	5.39
Average		**10**	**3.40**	**15**	**0.00**	**1.43**	**29.83**	**0.88**	**160.72**	**141.43**	**111.60**	**4.74**
*T_G	T_{G1}	10	2.50	15	0.00	2.50	30.00	4 pieces	28.86/ piece	115.44	85.44	3.85
	T_{G2}	10	2.50	15	0.00	2.50	30.00	2 pieces	28.86/ piece	57.72	27.72	1.92
	T_{G3}	10	2.50	15	0.00	2.50	30.00	5 pieces	28.86/ piece	144.30	114.30	4.81
	T_{G4}	10	2.50	15	0.00	2.50	30.00	3 pieces	28.86/ piece	86.58	56.58	2.89
	T_{G5}	10	2.50	15	0.00	2.50	30.00	4 pieces	28.86/ piece	115.44	85.44	3.85
		10	**2.50**	**15**	**0.00**	**2.50**	**30.00**	**3.6 pieces**	**28.86/ piece**	**103.90**	**73.90**	**3.46**

Notes: *R=Replicates, T_A=Bean, T_B=Cowpea, T_C=Tomato, T_D=Kangkong, T_E= Spinach, T_F= Long coriander, *T_G=Bottle gourd,* In case of T_G(*Bottle gourd*) was sold unit of price per piece.* Net income is estimated as the total income minus total cost. **Benefit- cost ratio is estimated as income divided by total cost. Each value under expenditure and revenue represent the seasonally expenditure and revenue except tub cost over a rotation length of 6 months. This experiment includes an allowance for unpaid labor of the experiment treatment estimated at the present wage rate (wage rate/ day; male Tk.200) and every day one labor has prepared 20 *tukri*.

Modification of adaptation strategies

Dais/ stage adaptation

Stage preparation technique is a completely new farming system in Bangladesh. An effort of practicing stage on the pond or any other flooded area has been given here. Stage was established (a platform for keeping the plants on top bed) by a piece of bamboo. In stage establishment, the first of six bamboo post was driven into the soil below the water of the pond at a proper distance mainly 5-6 ft away from each other. After then two bamboos were parallel arranged on the post of bamboo tied by plastic ropes to strengthen the stage. Then other bamboos were parallel arranged across the parallel two bamboos tied by plastic ropes. Similarly bamboo sticks were crossly arranged to prepare the stage for a platform of plants *tukri*. *Tukris* were put on the stage for cultivation of crops on the pond or flood affected area. Lastly, we harvested crop from stage manually or with knife. Collected agro crops were mainly adult feeding part of crops, not the whole plant. Crops were harvested several times from a *tukri* in this way (Figure-3).

Fig-a

Fig-b

Figure-3: Clockwise stage preparation and their adaptation technique (Fig-a: Bamboo stage made on the pond and tukri a side-view gathers on the stage; Fig-b: Shows dais adapting system with the crop on the stage).

Raft adaptation

Raft (locally known as *Vella*) technique is a completely new farming system in flood prone areas of Bangladesh. An effort of practicing raft has been taken here. *Tukri*s were shifted on the raft in the pond or *haor-baor* or river side or others flooded area. Raft (a platform for keeping *tukri* bed) established by piece of banana logs. At first some proper size banana trees were cut for making rafts, and then connect them with bamboo through banana logs. After then *tukri*s *were* settled on the banana raft which float on the flooded water of the flooded areas (Figure-4).

Fig-a

Fig-b

Figure 4: Clockwise raft preparation and their adaptation technique (Fig-a: overview banana raft on the water; Fig-b: Show raft adapting system on water with crop)

Heap made on the plain land

The heap preparation technique may be an old farming system in the flood prone areas in Bangladesh. An effort of practicing heap in the pond side has been described here. If whole land is flooded, *tukris* can be settled on the heap land (locally known as *kandi*). But the dry condition a hole was dug on heap land and the *tukri* put on them. The size of the hole was as same as the *tukri* size. Small pieces of water hyacinth were also given in the hole which may turn into organic manure after a few days. In this way half of the hole was filled with a small piece of water hyacinth. When tukris were settled within the opening, then the gap was filled with soil very tidily. Creeping and spreading agro crop was supported by a bamboo stem (locally known as *jhar*) (Figure-5).

Fig-a

Fig-b

Fig-c

Fig-d

Figure 5: Clockwise heap adaptation technique (Fig-a: Show heap adapting system over-view and *tukri* to settle on heap land; Fig-b: Digging for *tukri* set up in a hole on the heap land; Fig-c: Pressure by foot on water hyacinth based on indigenous system; Fig-d: Adapting condition and use support bamboo as *jhar*).

Heap made on the water logged condition

It is also a heap adaptation made on waterlogged condition of the pond. Hanging preparation technique is partly familiar in the flood prone areas of Bangladesh. An effort of practicing hanging system on the ponds, *hoar* or *boar* side of flooded area has been described here. It was made of water hyacinth or water weeds which were piling on the waterlogged area. The maximum size of which was 2.5 ft wide 3 ft long and 6 ft depth. Then *tukri* to settle on the stack of the water hyacinths (locally known as *dibi*). After that at the side of the stack a platform for creeping plants to shoot up and spread (locally known as *jangle*) had established by bamboo. In the jangle establishment, at first six pieces of bamboo were driven into the soil below the water of the pond at a proper distance mainly 6-7 ft away from each other. After then two bamboo pieces were parallels tied by plastic ropes for strengthen of the *jangle* then again another two bamboo pieces were parallel tied by plastic ropes. Similarly bamboo sticks were crossly arranged to prepare the platform for creeping plants to shoot and spread. Finally crops from the *jangle* were harvested by manually or through knife (Figure-6).

Discussion

The indigenous knowledge system is the main basis of the climate change adaptation strategies for agro crop production and it ensures the financial aptness for flood prone areas of the northeastern part of Bangladesh. The most significant aspect of the results is developed from different climate change adaptation strategies in farming system for production of common agro crops as well as their financial suitability of the study area. According to indigenous knowledge system, in our study we found that by identifying the best developed adaptation strategies and assess the financial suitability of farming system for production of common agro crops can be ensured.

Fig-a **Fig-b**

Figure 6: Clockwise preparation and their adaptation technique (Fig-a: overview prepared of bamboo jangle and dibi on the water; Fig-b: Show adapting system on waterlogged condition and crop is being creeping and spread with support as jhar)

A similar finding was reported of BCAS (2006) that, the farmers in many floodplain have found various ways of improving their climate change adaptation strategies in farming system and adopted floating gardens (locally called baira) for growing agro crops. If the local poor farmer prepare baira and get involved in the marketing of agro crops, they would be benefited of the season in the Beel areas. Baira cultivation promotes the local technique, helping in conserving indigenous knowledge. It has been practiced in some parts of Bangladesh such as Gopalganj, Barisal and Pirojpur as well as other territories. The results of these studies were supported by some researchers (Haq *et al.*, 2005; Haq *et al.*, 2002; Ghosal and Haq, 2000), who described the soil-less agriculture is an indigenous practice in the central southwestern part of Bangladesh. This study corroborates the findings of Rasid and Mallik (1995) regarding agricultural cropping patterns and related development strategies. Moreover, some researchers (Green *et al.*, 1994; Haq *et al.*, 2004) who reported that the most benefit can be achieved with less input. Household income level has a close link to coping strategies and can readily help them in a flood event and therefore is less vulnerable to flood impacts.

Also, our findings were agreed with (Nyong *et al.*, 2007) who reported the local farmers have developed adaptation strategies that enable reduce their vulnerability to climate variability. The farmers are considered that financial suitability is the most important indicator of adaptive capability. The indigenous knowledge systems offer great prospects that will be attractive enough to the vast majority of small-scale farmers who are required to apply them.

In some cases, we found that some of developed adaptation strategies have been more effective in the study area but it is a complex process and financially more costly. They are linked to others as ecological, social or economic condition. These findings coincide with Paul and Routray (2010) that traditional strategies make a positive contribution to improving people's adaptability to a flood hazard, but as a whole, it is a complex process, linked to other physical and socioeconomic variables.

Although our research is gradually recognizing the importance of indigenous knowledge systems in developing climate change strategies have received little attention, Indigenous knowledge systems create a moral economy

(Nyong *et al.*, 2007). People's indigenous adapting strategies can significantly reduce their vulnerability to disaster. However, such strategies are highly effective only in a normal situation: when floodwaters rise and cross a critical threshold, people have no choice but to migrate to a safer place (Paul and Routray, 2010).

Indeed, farmers in our study site still prefer their self developed different climate change adaptation strategies in farming system for production of common agro crops because it is their indigenous knowledge system and in the short term it gives relatively stable net cash flow each year.

Conclusion

The South Asian Bangladesh is a low-lying country, however, she is known globally as one of the most vulnerable countries to climate change. According to the prediction of scientists in the near future the negative impacts of climate change could be more dangerous. In this situation mitigation is impossible because a favorable return back is a lengthy process. So we need to improve our adaptation strategies. This paper has discussed climate change adaptation strategies for flood prone areas of Bangladesh. It is a severe flood affected country. Experience shows that some floods in the agricultural sector can be a cause of huge losses. Adaptation strategies have the potential to alleviate adverse impacts, as well as to capitalize on new opportunities posed by climate change. A few adaptation options have also been identified. These options will pay a favorable return even if the climate change does not occur. The present experiment is found to be the best adaptation option as well as a kind of new farming system which provides high yielding agricultural production helping flood affected people. The cost-benefit analysis of the experiment reveals that options are financially sustainable. The benefit-cost ratio (BCR) is also satisfied that is calculated for a certain period.

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References

Ali, A. (1999). Climate change impacts and adaptation assessment in Bangladesh. Space research and remote sensing organization (SPARRSO). *Climate Research*, 12, 109–116.

Banglapedia, (2012). *Banglapedia*, National Encyclopedia of Bangladesh. Available at http://www.banglapedia.org/HT/J_0051htm,http://www.banglapedia.org/HT/S_0682.htm Accessed on June 26, 2013.

Barnett, J. (2003). Security and climate change. Global environmental change, 13, 7–17.

BCAS (2006). Bangladesh centre for advanced studies. *Bangladesh wetland ecosystem -information and knowledge base. Dhaka*, Bangladesh, Available at http://ekh.unep.org/?q=node/2208. Accessed November 27, 2011.

Few, R., Osbahr, H., Bouwer, L. M., Viner, D., & Sperling, F. (2006). *Linking climate change adaptation and disaster risk management for sustainable poverty reduction*. Synthesis Report, Vulnerability and adaptation resource group (VARG), European commission.

Ghosal, T. K., & Haq, A. H. M. R. (2000). Hydroponics-an approach for wetland management. In: Jana, B. B. Banerjee, R. D. B. Guterstam and Heeb, J. (eds) *Waste recycling and resource management in the developing world: ecological engineering approach*, University of Kalyani, India. International ecological engineering Society, Switzerland. pp. 511-513.

Green, C., Veen, V. D. A., Wierstra, E., & Penning-Rowsell, E. (1994).

Vulnerability refined. Analyzing full flood impact. In E. C. Penning-Rowsell and M. Fordham (Eds.) *Floods across Europe. Flood hazard assessment*, modeling and management. London, pp. 32–68.

Haq, A. H. M. R. Ghosal, T. K., & G. Pritam (2004). *Cultivating wetland in Bangladesh*, LEISA Magazine, 20(4): 18-20. Available at http:// www.leisa.info. Accessed on August 12, 2011.

Haq, A. H. M. R., Pritam, G., & Islam, M. A. (2005). *Wise use of wetland for sustainable livelihood through participatory approach*. A case of adapting to climate change. Asian wetland symposium (AWS), Innovative approach to sustainable livelihood, February 6-9. 2005, Bhubaneswar, India.

Haq, A. H. M. R., Asaduzzaman, M., & Ghosal, T. K. (2002). *Soil-less agriculture in Bangladesh*. A Grameen trust, Bangladesh publication under the component of research for poverty alleviation. Grameen Bank Bhaban, Dhaka, Bangladesh, p. 111.

Hossain, M. (1990). *Natural calamities, instability in production & food policy in Bangladesh*. The Bangladesh development studies, Dhaka, Bangladesh, 18: 33-54.

IPCC (2007). *Intergovernmental Panel on Climate Change. Summary for policy makers. In. B. Metz., O. R. Davidson., P. R. Bosch., R. Dave, and L. A. Meyer, Climate change* (2007). Mitigation. contribution of working group III to the fourth assessment report of the Intergovernmental Panel on Climate Change, Cambridge, USA.

Mundy, P., & Compton, L. (1991). *Indigenous communication and indigenous knowledge*. Development Community Report, 74(3), 1–3.

Nyong, A., Adesina, F., & Elasha, B. O. (2007). *The value of indigenous knowledge in climate change mitigation and adaptation strategies in the African Sahel*. Mitigation and adaptation strategies for global change, 12, 787–797.

Ogata, S., & Sen, A. (2003). Human security now, commission of human security. Commission on human security, New York.

Osunade, M. A. (1994). Indigenous climate knowledge and agricultural practices in South western Nigeria. *Journal Tropical Georgephy*, 1, 21–28.

Paul, S. K., & Routray, J. K. (2010). Flood proneness and coping strategies: the experiences of two villages in Bangladesh. *Disasters*, 34(2), 489−508.

Rasid, H., & Mallik, A. (1995). Flood adaptations in Bangladesh. Is the compartmentalization scheme compatible with indigenous adjustments of rice cropping to flood regimes? *Applied Geography*, 15(1), 3–17.

UNDP (2004). *United Nations Development Programme*. User’s guidebook for the adaptation policy framework. P. 33.

UNFCCC (2007). *United Nations Framework Convention on Climate Change. Climate change*. Impacts, vulnerabilities and adaptation in developing countries. Climate Change Secretariat, Bonn, Germany. Available at: *http://unfccc.int/resource/docs/publications/impacts.pdf*. Accessed on November 21. 2010.

Warren, D. M. (1992). *Strengthening indigenous Nigerian organizations and associations for rural development: the case of Ara community*. Occasional Paper, African resource centre for indigenous knowledge, No. 1.

Woodley, E. (1991). Indigenous ecological knowledge systems and development. *Agriculture human values*, 8, 173–178.