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Land Air Temperature Variability and Climate Change

A case study of Bangladesh

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Editorial Office, International University of Business Agriculture and Technology (IUBAT)
4 Embankment Drive Road, Sector 10,
Uttara Model Town, Dhaka 1230, Bangladesh
Tel: (+88) 55091801, 55091802, 55091803, 55091804, 55091805
E-mail: ijournal@iubat.edu

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Prof. Md. Monirul Islam, PhD

Editors' Note

The IUBAT Review is a multidisciplinary academic journal that the editors intend to publish annually. The office of the Journal is located at the International University of Business Agriculture and Technology, the first non-government university in Bangladesh. It was founded in 1991 as a not-for-profit institution. The university's mission is to develop human resources through quality education.

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Analysis of Land Air Temperature Variability and Climate Change

A case study of Bangladesh

Md. Monirul Islam
IUBAT – International
University of Business
Agriculture and Technology
Uttara, Dhaka 1230

ABSTRACT: *Monthly time series (1971 to 2007) of Land Air Temperature (LAT) data were analyzed for Bangladesh. Monthly mean LAT anomalies and synoptic anomalies were determined for analyzing the LAT variability. The effect of El Nino and La Nina were also observed by using synoptic anomalies of LAT anomalies. Positive trend of LAT was established from the 37 years (1971-2007) LAT data by using synoptic anomalies. Statistical model was used to find out the best probability distribution function (PDF) for the selected study area. The warmer or cooler trends of LAT were discussed and the Log-normal curve was selected as the best-fitted PDF curve for Bangladesh. From the trends analysis it was deduced that the weather of Bangladesh getting warmer.*

KEYWORDS: *Climate change, Land Air Temperature (LAT), Environment, Temperature variability, Probability Distribution Function (PDF), Meteorology, Thermodynamics, Atmosphere and Weather*

Introduction

Determining the long-term variability in sea surface temperature (SST) and land air temperature (LAT) is important. They provide information about ocean current flow, probable distribution of sea life and land life, global energy budget, and weather and climatological trends. The use of estimated SAT has provided an enormous leap in our ability to view the spatial and temporal variation of LAT. Scientists have long yearned to decipher all the physical processes occurring in the ocean and land surface area. Over the past century, researchers have been analyzing LAT and SST variability (Xue and Shukla, 1996; Caron and O'Brien, 1998; Chelton and Davis, 1982; Smith et al., 1996; Chu et al., 2000). Interannual variability in LAT and SST has mainly been attributed to local thermodynamic interactions between the atmosphere and land and ocean (Gill and Niiler, 1973; Frankignoul and Reynolds, 1983; Frankignoul, 1985; Battisti et al., 1995, Delworth, 1996). Therefore, many researchers developed models by using SST and near-surface air temperature anomalies. To enable longer-term modeling, such models have been compared to atmospheric general circulation models (AGCM), simulations in which the land atmosphere is coupled to an ocean model in which the climatological SSTs are specified as boundary conditions (Bhatt et al., 1998; Saravanan and McWilliams, 1997). Comparatively less study has been undertaken of LAT variability arising from climate changes. Weare (1994) and Klein et al. (1995) showed that there is a strong positive feedback between anomalies in the large-scale temperature pattern and low-level stratus clouds: an increase in stratus clouds reduces the solar radiation reaching the surface, which reduces temperature and thereby increases the static stability of the boundary layer, a factor that tends to enhance cloudiness. Zhang et al. (1997) and Norris et al. (1998) have suggested that this positive feedback can lead to persistence of temperature anomalies from both summer to winter and winter to summer. Local processes within the upper ocean or land surface, such as the seasonal variation in the depth of the surface mixed layer, may also lead to temperature variability.

Bangladesh is one of the worst victim regions of climate change and El Niño/La Niña impacts. The existing geophysical and socioeconomic setting of the country increases both the vulnerability and severity of the events discussed above. The country's agricultural economy depends mainly on climatic phenomena. Bangladesh is perhaps the most unique country in the world where casualties resulting from a cyclone can rise into the hundreds of thousands. For example, the October 1970 cyclone killed an estimated 500,000 people and the April 1991 cyclone killed an estimated 140,000. Sidr in 2007 fortunately landed at low tide. It killed an estimated 3,400 and damage cost was about USD450 million. Monsoon floods can devastate more than half the country causing damage in the billions of dollars. Nor'wester storms and tornadoes often demolish settlements in many parts of the country. There is a correlation between El Niño (above-normal SST) and La Niña (below-normal SST) events and variability of climatic phenomena (Islam et al., 2003). This study correlates El Niño/La Niña events and vari-

ability of climatic phenomena in the country, using the synoptic LATA.

Considerable efforts have been made to analyze LAT variability by using synoptic anomalies of LAT. Here, I use monthly mean LAT data from 1971 to 2007 for six divisions and the whole area of Bangladesh to understand the annual and seasonal variability of Bangladesh and develop statistical models for probability distribution function (PDF) of temperature anomalies.

Study Area and Basic Data

Bangladesh is a transition zone between Southwest and Southeast Asia. It forms the capstone of the arch formed by the Bay of Bengal, and because of the Tibetan plateau (massif) to the north, it is a comparatively narrow land bridge between the sub-continent of South Asia and sub-continent of Southeast Asia. More precisely, the country stretches latitudinally between 20° 34' N and 26° 33' N and longitudinally between 88° 01' E and 92° 41' E. To analyze the country-wide, divisional and also seasonal trends of LAT, monthly mean LAT data from 1971 to 2007 (total of 37 years) were collected from 34 different observatory stations of the Bangladesh meteorological department. We interpolated for some missing data by using a simple Gaussian technique to unify with other data.

Methology

Monthly Mean LAT Anomalies

Mean monthly anomalies were estimated by the following equations (Chu, P. C. et al., 1997, Islam, M. et al. 2005):

$$T_a(x_i, y_j, t_l) = T_m(x_i, y_j, t_l) - T_{em}(x_i, y_j)$$

$$T_m(x_i, y_j, t_l) = \frac{1}{\Delta_X} \sum_{1971}^{2007} T(x_i, y_j, X_k, t_l)$$

$$\Delta_X = 37 = [(2007 - 1971) + 1]$$

$$T_{em}(x_i, y_j) = \frac{1}{12} \sum_{l=1}^{12} T_m(x_i, y_j, t_l)$$

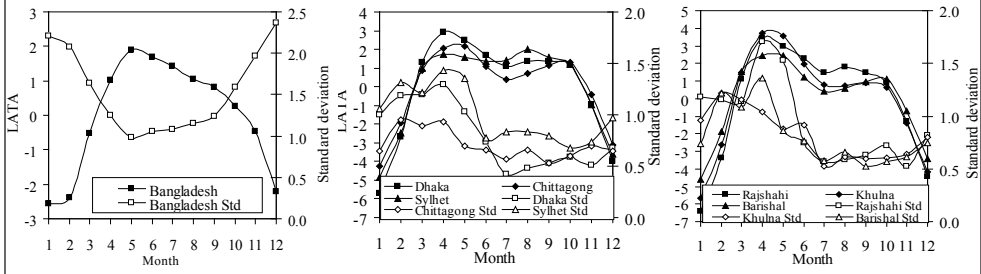
where, T_a represents mean monthly LAT anomalies (LATA), T_m long-term monthly mean, T_{em} ensemble mean of LAT. T represents the matrix of LATs in each of 34 observatory stations and 444 months; (x_i, y_j) is the station latitude and longitude; X_k (= 1971, 1972,…...2007) is the time sequence in years, and t_l (= 1,2,…….12) is the monthly sequence within a year.

Synoptic anomalies were estimated by:

$$T_{sa}(x_i, y_j, X_k, t_l) = T(x_i, y_j, X_k, t_l) - T_m(x_i, y_j, t_l)$$

where, T_{sa} represent synoptic anomalies. Figure 1 plots the long-term LATA average and the standard deviation for LATA for the whole country and the six (old) divisional regions: Dhaka, Chittagong, Sylhet, Rajshahi, Khulna, and Barisal. From March to October the LATA are positive for all divisions; from November to February they are negative. For Bangladesh overall and most divisions, the standard deviations of LATA observations in summer months are lower than in winter. The synoptic LATA plots depict months that are warmer or cooler than the climatic normal for the particular month.

Figure 1: Long-term LATA average for whole country and six divisions



(a) Whole Bangladesh (b) Dhaka, Chittagong, Sylhet Division (c) Rajshahi, Khulna, Barishal Division

The monthly synoptic LATA variations over the whole area of Bangladesh for the years 1971 to 2007 are shown in Figure 2. From this figure, the trend of monthly mean temperature can be calculated. The zero line parallel to the horizontal-axis indicates the climatic average LAT for each observation station for each month. The trend line equation (5) was derived from synoptic LATA (in Fig. 2) as follows:

$$\left.\begin{aligned} TL &= 0.0016x - 0.36 \\ \text{where } x &= T_{sa} \end{aligned}\right\} \qquad (5)$$

The trend line shows a positive gradient: 0.0016°C/month, which indicates that Bangladesh weather has been getting warmer over the four decades. Bangladesh seasons are broadly classified as winter or northeast monsoon, summer or pre-monsoon, southeast monsoon or monsoon and autumn or post monsoon (Habib, A. 2011). Seasonal synoptic LATA were also obtained by using Eq. 4. for winter or northeast monsoon (December to February), summer or pre-monsoon (March to May), southeast monsoon or monsoon (June to September) and autumn or post-monsoon (October to November) (Habib, A. 2011). Seasonal variations of synoptic LATA for the four seasons are shown in Figure 3.

Figure 2: Synoptic anomalies for Bangladesh from 1971 to 2007

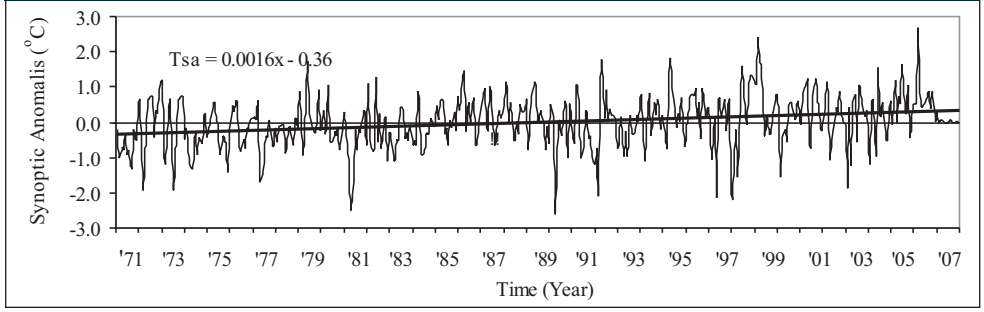
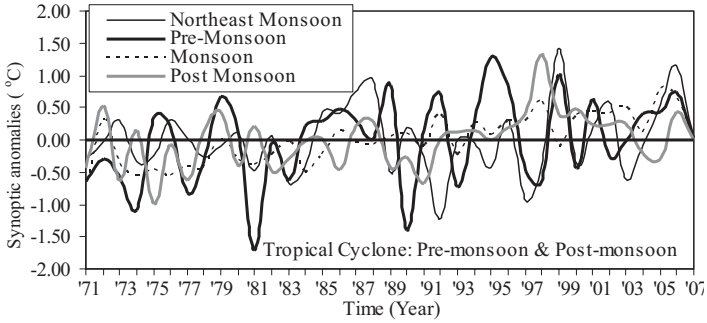


Figure 3: Seasonal Synoptic Anomalies

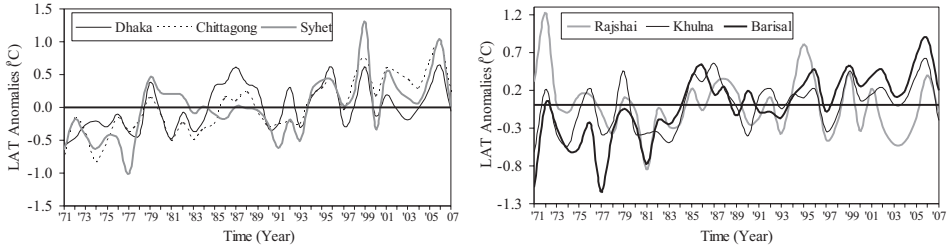


Effect of El Niño and La Niña on SSTA

Scientists have found complex correlations between El Niño/La Niña events and variability of climatic phenomena. Such events are associated with higher incidence of natural disasters, such as those mentioned above. The changes in LAT and SST are caused by local heat exchange and heat transport in accordance with advective diffusivity in the land area and ocean. The biennial variation of SST is largely related to the marked climate change systems, such as El Niño Southern Oscillation (ENSO), the biennial change of monsoon and rainfall in tropical ocean. ENSO is a biennial see-saw in tropical sea level pressure between the eastern and western hemisphere with the center of action located over Indonesia and the tropical South Pacific Ocean (Philander, 1999). The Southern Oscillation Index (SOI) is the sea level pressure difference between Darwin (12.4^{o}S, 130.9^{o}E) in northern Australia and Tahiti (17.5^{o}S, 149.67^{o}W) in the South Pacific Ocean. Large negative values indicate a cool event (La Nina) and large positive values indicate a warm event (El Nino). Fig. 3 shows the positive and negative values of synoptic anomalies with time period from 1971 to 2007 for different monsoon seasons, and Figure 4(a) and (b) show the long-term temperature anomalies for the six division of Bangladesh. The comparison between El Niño and La Niña events (years) and their effects on the temperature variations are summarized in Table 1 (see Fig. 4). .

Figure 3 exhibits negative anomalies for pre-monsoon and northeast monsoon in 1997-98. The pre-monsoon period is characterized by cyclogenesis in the Bay of Bengal. In this period, a depression may develop into a cyclone. Cyclones travel generally northwest initially, and then turn to the northeast towards the coast of Bangladesh and Myanmar. Some of these storms may attain hurricane intensity and are associated with storm surges. (A devastating cyclone hit Bangladesh in April 1991.) Figure 3 exhibits positive synoptic anomalies for post monsoon, pre-monsoon and northeast monsoon and normal for monsoon season in the year of 1988-89 periods.

Figure 4: temperature anomalies for six division of Bangladesh



Statistical Analysis

Mean Value and Standard Deviation

We estimated the mean, variance and standard deviation of monthly mean LAT for the six divisions of Bangladesh. Figure 5 shows the plots of standard deviation and monthly mean LAT average over the selected area of each division. A high mean value temperature indicates warm weather and low mean value indicates cooler weather. A high standard deviation indicates frequently changing weather and low standard deviation indicates more stable conditions (Islam and Sado,2002). On the basis of this model the summarized results are shown in Table 2

Probability Distribution Model

We have estimated relative frequency of monthly mean LAT data for all stations over the countries. Four probability frequency distributions (PDFs) were considered as options for modeling (Caron and O'Brien, 1998). PDFs provide meaningful probability information for the distribution of each LAT (Bendat and Piersol, 1986, Montgomery and Runger, 1999). The four PDFs fitted were the Normal (Gaussian), Log-normal, Extreme values distribution (maximum and minimum).

Figure 5: Monthly mean and standard deviation of LAT

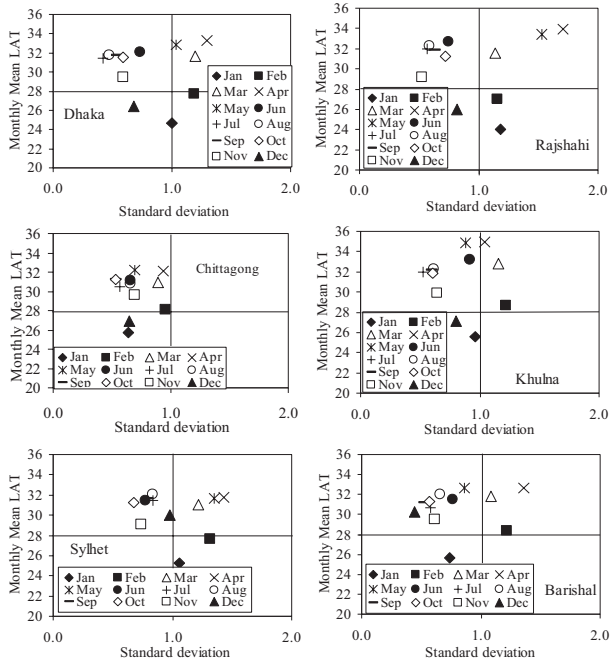


Table 1: Results from mean temperature and standard deviation model for six divisions

	High Temperature (T>28'C)		Low Temperature (T<28'C)	
Divisions	**Stable (std dev. <1)**	**Unstable (std dev. <1)**	**Stable (std dev. <1)**	**Unstable (std dev. <1)**
Dhaka	Jun, Jul, Aug, Sept, Oct	Mar, Apr, May	Dec	Jan, Feb
Chittagong	Mar, Apr, May, Jun, Jul, Aug, Sept, Oct, Nov		Dec, Jan, Feb	
Sylhet	Jun, Jul, Aug, Sept, Oct, Nov	Mar, Apr, May		Dec, Jan, Feb
Rajshahi	Jun, Jul, Aug, Sept, Oct	Mar, Apr, May	Dec	Jan, Feb
Khulna	Jun, Jul, Aug, Sept, Oct, Nov	Feb, Mar, Apr	Dec, Jan	
Barishal	May, Jun, Jul, Aug, Sept, Oct, Nov, Dec	Feb, Mar, Apr	Jan	

T: Mean Temperature, std dev.: standard deviation of mean temperature

PDFs have the important characteristics that

$$\sum F(x)\Delta x = 1 \qquad (6)$$

where, F(x) represents the probability and Dx is the sampling interval. The relative frequency of monthly mean LAT for whole area of Bangladesh was estimated, and each of the above four PDFs was fitted to the data. The root mean square error (RMSE) displayed the best fit in the case of the following log-normal [x=0.8769(logT-3.342): N(0, 1)], with RMSE=0.038°C, as shown in Figure 6.

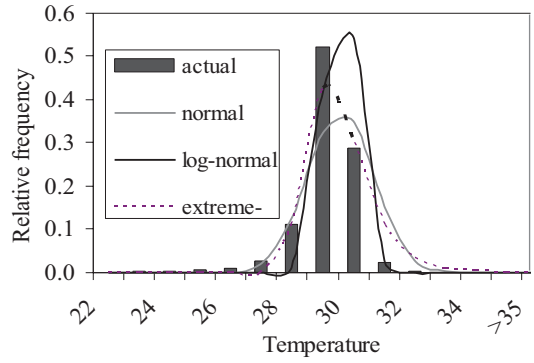
Results and Discussion

The monthly means LATs have been analyzed to observe the characteristics of the LAT pattern for the six divisional regions and the whole country. The linear relations between predicted and observed values for frequencies are shown in Figure 6.

Mean Value and Standard Deviation

Monthly mean values of standard deviation for LATA for the whole country (in Fig. 1(a)) decrease from highest (2.07°C) in January to lowest (0.98°C) in May, and increase from lowest in May to highest (2.37°C) in December; monthly mean LATA values follow the reverse curve from January to December [Fig. 1]. But for different divisional data, standard deviation curves maintain the same characteristics with LATA curves (in Fig. 1(a) & 1(b)) except the month of January to March. All six divisions of Bangladesh exhibit high monthly mean temperature (>28°C) for six months of the year with stable weather. Dhaka, Chittagong, Sylhet and Rajshahi show the unstable weather with high temperature in the months of March, April and May while Khulna and Barishal show the unstable weather with high temperature in the month of February, March and April [Fig. 5 and Table 1].

Figure 6: Probability distribution functions for best-fitted curve of relative frequency of LAT



Anomalies

The synoptic LATA (in Figure 2) shows the positive slope of the trend line, which indicates the increase of temperature with time. Monthly mean LAT variation ranges from –2.6° to +2.7°C shown in Figure 2. No variation in mean temperature over the 37 years would yield a trend line following the zero line. However, the fitted trend has a positive coefficient of 0.0016°C per month. That implies an increase in predicted mean of 0.71°C from 1971 to 2007.

Seasonal Variation of Anomalies

Figure 3 shows that the northeast monsoon period exhibits the highest positive (1.42°C) synoptic anomalies, followed by the post-monsoon periods of 1999 and 1998, while the highest negative (1.71°C) synoptic anomalies are exhibited for the pre-monsoon period in 1981 followed by the pre-monsoon period in 1990 and by northeast monsoon period in 1992. Figure 4 shows the variation of LATA for six different divisions of Bangladesh. Among the six divisions, Sylhet shows the significant variation of temperature from climatic normal (1.3°C to -1°C) compare with others divisions followed by Rajshahi division (1.2°C to -0.8°C).

Effect of El Niño and La Niña Analysis by Synoptic LATA

Both El Niño and La Niña impact global climate patterns. In many locations, especially in the tropics, La Niña (cold episodes) produces the opposite climate variations from El Niño (warm episodes). For instance, parts of Australia and Indonesia are prone to drought during El Niño, but are typically wetter than normal during La Niña. La Niña is characterized by unusually cold ocean temperatures in the equatorial Pacific, as compared to El Niño, which is characterized by unusually warm ocean temperatures in the equatorial Pacific. Typically, a La Niña event is preceded by a buildup of cooler-than-normal subsurface waters in the tropical Pacific. Eastward-moving atmospheric and oceanic waves help bring the cold water to the surface through a complex series of events still being studied. In time, the easterly trade winds strengthen, cold upwelling off Peru and Ecuador intensifies, and sea-surface temperatures (SSTs) drop below normal. Table 1 shows the effect of El Nino and La Nina on Bangladesh over the years, which was summarized from the Fig. 3 and Fig. 4 considering whole area of Bangladesh for different monsoon seasons and for six different divisions. Figure 4 shows the positive synoptic anomalies in the period of El Nino years; 1986-1987, 1994-1995,1997-1998 and 2001-2002 and negative synoptic anomalies in the period of La Nina years; 1973-1974, 1975-1976, 1984-1985 for six divisions of Bangladesh (Table 1).Considering the above mentioned results, it can be comprehended that the effect of El Niño and La Niña by analyzing Synoptic LATA can be apprehended.

Concluding Remarks

The area of different divisional areas experience different weather conditions. The trends of LAT are related to the changes in air circulation and local thermodynamic interactions between the atmosphere and upper surface of the lan and Ocean (Gill and Niiler, 1973; Frankingnoul and Reynolds, 1983; Frankingoul, 1985; Battisti et al., 1995; Delworth, 1996). Our selected study area is therefore influenced by local thermodynamics and the circulation system of Bay of Bengal and Indian Ocean. That is why we have divided whole Bangladesh into its old six divisional region of Dhaka, Chittagong, Sylhet, Rajshahi, Khulna and Barisal. Summarizing, our results suggest that the existence of warming trends of LAT in Bangladesh and of its six divisions also. The variation of LAT is

very much scattered for Sylhet then followed by Rajshai and Barisal.

The standard deviation and mean value for LAT and LATA corresponding with the month of January to December show good correlation with the stable weather with high temperature (LATA with month and standard deviation in Fig. 1(b) and (c) show the values decreasing from highest to lowest and increasing from lowest to highest, respectively) except the month of February to May which exhibit unstable weather with high temperature (in Table 1) (cyclone normally hits Bangladesh in this period. Using monthly mean LAT and standard deviation the seasonal variation such as northeast monsoon (winter), pre-monsoon (summer), southeast monsoon (monsoon) and post-monsoon (autumn) also can be co-related and comprehended. PDFs could be also modeled for seasonal variation and also for a particular month separately. LAT variability and the effect of El Niño and La Niña were observed by using synoptic LATA. Therefore, the long-term LAT variability and the effects of El Niño and La Niña can be comprehended by using the synoptic anomalies of LAT and SST of Bay of Bengal and Indian Ocean.

The analysis of Effect of El Niño and La Niña and analysis of cold and warm episode not only depends on temperature but also depends on wind stress, rainfall and SST. Therefore, to study climatic change and the effect of El Niño and La Niña in the region, abovementioned data have to be correlated and analyzed by using cross correlation method.

Reference

Battisti, D. S., Bhatt, U. S. and Alexander, M. A., 1995. A modeling study of the interannual variability in the wintertime North Atlantic Ocean. *J. Climate*, 8, 3067-3083.

Bendat, J. S. and Piersol, A. G., 1986. *Random Data Analysis and Measurement Pro*cedures. Wiley-Interscience. 566pp.

Bhatt, U. S., Alexander, M. A., Battisti, D. S., Houghton, D. D. and Keller, L. M., 1998. Atmosphere-ocean interaction in North Atlantic: near-surface climate variability. *J. Climate*, 11, 1615-1632.

Caron, J. M. and O'Brien, J. J., 1998. The Generation of Synthetic Sea Surface Temperature Data for the Equatorial Pacific Ocean. *American Meteorological Society*, 126, 2809-2821.

Chelton, D. B. and Davis, R. E., 1982. Monthly mean sea-level variability along the west coast of North America. *J. Phys. Oceanogr.,* 12, 757-784.

Chu, C. P., Lu, S. and Chen, Y., 1997. Temporal and spatial variabilities of the South China Sea surface temperature anomaly. *Journal of Geophysical Research,* Vol. 102, Issue C9, 20937-20955.

Delworth, T., 1996. North Atlantic interannual variability in a coupled ocean-atmosphere model. *J. Climate*, 9, 2356-2375.

Frankignoul, C., 1985. Sea surface temperature anomalies, planetary waves, and air-sea feedback in the middle latitudes. *Rev. Geophys.*, 23, 357-390.

Frankignoul, C. and Reynolds, R. W., 1983. Testing a dynamical model for mid-latitude sea surface temperature anomalies. *J. Phys. Oceanogr.*, 13, 1131-1145.

Gill, A. E. and Niiler, P. P., 1973. The theory of the seasonal variability in the ocean. *Deep Sea Res.*, 20, 141-177.

Habib, A. 2011.Climate Change: Bangladesh Perspective, Bangladesh Metrological Department, Dhaka, Bangladesh, www.dccc.iisc.ernet.in/22July2011-Policy/Arjumand-Habib.doc [Retrieved on 2017]

Islam M. M. and Soon, C. S., 2003, Use of SeaWiFS Browse Data for Cloud Coverage Analysis and Weather Study,Asian Journal of Geoibformatics, Vol. 3, No. 4, 43-49.

Islam M. M. and Sado, K., 2003. Time series analysis of SST for Java Sea and South China Sea using NOAA AVHRR data, Proceedings of the 34th Conference of Remote Sensing Society of Japan, College of Humanities and Science, Nihon University, edited by RSSJ, 155-156.

Islam M. M., Sado, K. and Soon, C. E. 2005. Analysis of Satellite Derived Sea Surface Temperature Data for South China Sea and Java Sea, Asian Journal of Geoinformatics, Vol. 5, No. 3, 12-23.

Klein, S. A., Hartmann, D. L. and Norris, J. R., 1995. On the relationships among low-cloud structure, sea surface temperature and atmospheric circulation in the summertime northeast Pacific. *J. Climate*, 8, 1140-1155.

Montgomery, D. C. and Runger, G. C., 1999. *Applied Statistical and Probability for Engineers*, Second Edition, John Wiley & Sons, Inc. 817 pp.

Norris, J. R., Zhang, Y. and Wallace, J. M., 1998. Role of low clouds in summertime atmosphereocean interactions over the North Pacific. *J. Climate*, 11, 2482-2490.

Philander S. G., 1999. El Nino and La Nina, Predictable Climate Fluctuations, Reports on Progress in Physics 62, 123-142.

Saravanan, R. and McWilliams, J. C., 1997. Stochasicity and spatial resonance in interdecadal climate fluctuations. *J. Climate*, 10, 2299-2320.

Smith, T. M., Renolds, R. W., Livezey, R. E. and Stokes, D. C., 1996. Reconstruction of Historical Sea Surface Temperature Using Empirical Orthogonal Function, *J. Climate*, 9, 1403-1420.

Wang, D., Xie, Q., Du, Y., W. Wang, 2003. 1997-1998 Warm Events in the South China Sea and its Interpretation URL: http://www.soc.soton.ac.uk/JRD/MET/WGASF/workshop/PDF/2p12dwang.doc.pdf, (Retrieved on 2003),

Weare, B., 1994. Interrelationships between cloud properties and SSTs on seasonal and interannual timescales. *J. Climate*, 7, 248-260.

Zhang, Y., Wallace, J. M. and Battisti, D. S., 1997. ENSO-like interdecadal variability. *J. Climate*, 10, 1004-1020.

Xue, Y. and Shukla, J. 1996. The influence of land surface properties on Sahel climate. Part II: Afforrestation. J. of Climate, American Meteorological Society, 3260-3275.

IUBAT Review
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Selina Nargis and Khandaker Iftekharul Islam. 2017. "Quality in Higher Education: An Empirical Investigation." *IUBAT Review* 1 (2): 17-28. iubat.edu/journal

Quality in Higher Education: An Empirical Investigation

Selina Nargis
Faculty, College of Arts and Sciences
Director Administration
IUBAT—International University of Business Agriculture and Technology
Uttara,1230

Khandaker Iftekharul Islam
Department of Civil Engineering
IUBAT—International University of Business Agriculture and Technology
Uttara,1230

ABSTRACT: *Higher education has a pervasive impact on the entire education system. However, to meet society's expectations of higher education, the question of quality becomes crucial. It cannot be overlooked.*

Quality depends on teaching methods and the institutional commitment to create an environment for learning. In addition to teachers, students need physical, social, cultural, and psychological security. Sometimes forgotten is that higher education students are adults. Teaching adults requires adult treatment. This paper is a case study of a leading non-government university in Bangladesh. It assesses the university's various aspects of quality assessment via a survey of opinion among faculty, students and alumni.

KEYWORDS: *Education, teaching, learning, learning environment, quality assessment, University*

Introduction

The need for quality in education in schools and colleges cannot be ignored. However, analysts have defined the concept in many ways. Authors have defined quality as 'elusive', 'slippery & value-laden' (Harvey and Green 1993). Scott (1994) asserts "no authoritative definition of quality in higher education is possible". Westerheijden (1999) stated that the literature on higher education lacks a theoretical framework. "In the last resort, quality is a philosophical concept," concludes Green (1994). Confusion is also created by inter-mixing words like quality and standard. Quality can be read as the process used in delivering education to students, while standards are measures of student learning outcomes. Educational process is conditioned by a set standard of higher education.

Quality has many dimensions (EAU Case Studies 2007). Different stakeholders in a higher educational institution have different perspectives. For faculty and students, the priority may be the process of education. However, the priority of the employers of graduating students may be the standards of higher education institutions. Observations on 'fitness for purpose' or 'value for money' frequently appear in the discussion of quality in higher educational institutions. However, none of these terms has a solid theoretical foundation. Pragmatic approaches to measuring quality have a comparative nature, using audits and accreditation assessments.

Quality in Higher Education

The premise of Knowles (1975, 1984a) is that adults are mature self-focused learners who can take responsibility for making learning decisions. Knowles conceives adult learners as having the following characteristics: (1) unlike children, the reason for learning needs to be clear; (2) adults learn more effectively through experience; (3) adults learn more in problem-solving mode; and (4) relevance of the topic to the immediate need is of prime importance. His term 'andragogy' emphasizes the educational process more than the content when teaching adults. In this approach, the faculty move away from the classical role of lecturer or evaluator and take on the role of a facilitator or learning manager in course delivery.

Following are some of Knowles's (1984b) principles of adult learning:

1. Consultative process in the design of the subject of study, method of delivery and grading contribute to better learning.
2. The process of learning activities moves away from theory to practice.
3. Relevance to job or life is of prime importance.
4. Content of the course has less attraction to adult learners; they are more interested in learning through problem-solving.

Miyan (2011) has emphasized the importance of quality of education and social accountability in the context of Bangladesh, a low-income country. Assessing quality of higher education is not easy, and the rising demand for post-secondary education has

created an opening unfortunately for low-quality institutions. They in turn lower the credibility of all Bangladesh higher education institutions. Earlier, entry to higher education was very restricted and maintenance of reasonable quality was not a major problem. Today, a dramatic increase has taken place in the number of universities in the country and the problem of maintaining quality looms as a much more significant problem.

In particular, the shift from "class to mass" in rural areas presents many quality problems. Rural schools and colleges rarely have modern teaching and learning aids; they have few lab facilities. Students nurtured in these circumstances can hardly be expected to flourish. Quality higher education institutions need to offer special remedial training to make up for early learning gaps.

Higher Education in Bangladesh

Until the early 1990s, higher education was entirely in the public sector. Government universities (GUs) had all the elements of a good university in terms of structures and systems. However, faculty and student politics, campus indiscipline, session jams, insufficient seats, outdated curricula and like issues were pervasive, which led to exodus of good faculty and encouraged financially solvent families to send their children to foreign universities.

This academic environment induced some leading academics, philanthropists and social thinkers in the late 1980s to explore alternative modes of higher education. Ultimately, this led to breaking the public sector monopoly on delivering higher education, by enacting the Non-Government University Act 1992.

Presently, there are 37 government universities (GUs) and over 80 non-government universities (NGUs) in Bangladesh. Of the GUs, five were established before the 1971 liberation of Bangladesh. All the NGUs have been established after 1991. As of 2012, the total number of students in the GUs was around 197,000 (leaving aside students in the affiliated colleges of National University and Open University), while the number of students in NGUs was around 315,000. This might be indicative of the relative capacity, public confidence and quality of NGUs relative to GUs.

Quality assurance has been a big challenge for the GUs due to campus politics. As more NGUs are being established and are delivering higher education to more students, NGU quality assurance has also come into question.

Methodology

The empirical investigation reported in this article has been carried out on the quality of a leading non-government university, namely IUBAT—International University of Business Agriculture and Technology, the pioneer among non-government universities in Bangladesh. It started operation in 1991 – and has operated continuously since 1991 – by sharing a charter with a foreign university; it received its own charter in 1993. IUBAT has students and/or graduates from 475 out of 491 *upazllas* of Bangladesh. Students from 134 *Upazllas* have required financial assistance, which indicates students come from families

with a fairly wide range of income. The university has fully equipped facilities for all its academic programs and presently has around 7,500 students in the Master's, Bachelor's and diploma programs.

This is not a survey of quality in all NGUs. It is a case study in the potential for good quality in a leading NGU. IUBAT is expected to have gained experience in both teaching and research. Another reason for selecting IUBAT is ease of access for collecting information for the study as both the authors belong to the faculty of the university.

In this investigation, we sought feedback from students, alumni and teachers using structured questionnaires. Separate questionnaires were used for each of the three groups. The questions were both open- and closed-ended. Additional information has been collected through review of publications, papers, and documents available in the IUBAT offices and library. We provide some detail on the three samples:

i. **Faculty:** The study included 30 (12.5% of the total) selected through random sampling. The study sample did not include any semester-based or visiting faculty members, who constitute a very small proportion of the total faculty.

ii. **Students:** 60 students were selected by cluster sampling. For clustering purposes we selected the time slot with the maximum number of scheduled classes. From the cluster of classes, we selected 30 classes representing junior, sophomore and senior students, covering all programs of the university. We requested that instructors of the selected classes select two students who in turn would complete the student questionnaire.

iii. **Alumni:** The study covered 30 selected through random sampling. From an updated list of numbered IUBAT graduates we used a random number table to select.

Secondary information has been collected through a review of documents available, through the IUBAT library and via discussion with administrators. Information has been collected on the syllabus, faculty, course outlines, class monitoring, course instruction, student attendance in class, teaching methods, student service, seminar and workshop, intellectual competition, research and development, and facilities available for delivering quality education.

Description of Quality Assurance Aspects of IUBAT

In this section, we discuss aspects of IUBAT administration relevant to quality assurance:

i. **Syllabus:** The IUBAT syllabi are constructed after consulting syllabi of different local and foreign universities. They are modified for the Bangladesh context. Course curricula have been standardized and are now recognized by other universities. Every four to five years, an overall curriculum review takes place. Every semester faculty review outlines of each course they teach. IUBAT has credit transfer agreements with several universities.

ii. **Faculty:** Teachers are selected by assessing their academic degrees and also by how well they can deliver their subject

matter in a demonstration lecture. Faculty selection is an elaborate process involving preliminary sorting of applications, individual interviews, assessment reports by subject experts and administrators, English language test, subject matter test, and information technology test. IUBAT promotes faculty development by, for example, encouragement to participate in local, national and international training, seminars, workshops and conferences. IUBAT bears the cost for participation in such activities within the country.

iii. **Course Outline:** The faculty member assigned to a course prepares a course outline, which is distributed to students on the first day of class. Outlines are preserved in the university library for future reference. Outlines allow students and administrators to assess the teaching material to be covered during the semester. Both faculty coordinators and the vice-chancellor review outlines. IUBAT has a generous budget for library procurement of required teaching materials.

iv. **Class Monitoring:** Each class is physically monitored to assure it takes place as scheduled and on time. Weekly, the Registrar prepares the statistics of classes held and those to be made up, if any. Missed classes are made up either through make-up lectures or by advance classes used as make-ups. The monthly class monitoring report is presented in the monthly meeting of the Academic Council.

v. **Students' Attendance:** If a student is absent, the instructor reports this to the registry and electronically sends an absentee report for the student. The registry office copies the report, keeps it in the student's file, and emails it to the student, to the student guardian, and to the program coordinator. This helps regularize student attendance. IUBAT regulations enable teachers to allocate 5 – 10 percentage points in grading for class attendance. If a student remains absent for more than three days in a course without a valid justification, the instructor may assign a failing grade in the course. With these academic regulations, the university maintains an average 90-95% attendance of students.

vi. **Course Instruction Survey (CIS):** Students complete a CIS on finishing each course. The CIS allows students to evaluate the course material, teaching efficiency and the extent to which the student considers he or she benefited from the course. Teachers are informed about the students' evaluation results. The CIS is a standard form and the data are processed through software. This process is extremely helpful in designing/redesigning courses and improving the teaching efficiency of instructors.

vii. **Methods of Curriculum Delivery:** English is the medium of teaching and communication in all IUBAT programs, communications and activities. IUBAT programs emphasize task-based and participative methods of instruction as well as use of modern teaching aids as supplement the classical instruction methods. The program emphasizes close interaction between teachers and students in formal

and informal situations. At admission, nearly all freshmen have limited English speaking ability. By the time they graduate (at the time of Practicum Defence examination), the scenario is reversed: 49% of students have moderate-to-good spoken English; 50% demonstrate excellent spoken English; only 1% perform poorly.

viii. **Student Service:** For career development as well as handling problems, students are offered special courses with credit. The Counseling and Guidance Centre helps students, for example those with difficulty in organizing practicum and job placement. (However, nearly all students get their practicum and job placement by their own efforts.)

ix. **Seminars and Workshops:** Seminars, workshops and conferences are regularly organized on national and international trends in teaching and learning processes.

x. **Intellectual Competitions and on-the-job opportunities:** Simple competitions among students encourage academic improvement in a way that students enjoy. There is also some potential for on-the-job experience, which also offers some financial benefit to students.

xi. **Research and Development:** At present, IUBAT undertakes limited research. However, IUBAT is encouraging more research activity: participation in national and international conferences, seminars, workshops; publication of working papers and articles. IUBAT has recently introduced a reward system for different categories of publication. While the library is adequate for student needs, many faculty members have requested expanded library facilities. There is an ongoing demand for greater online computer access. IUBAT has organized campus-wide WiFi acccess.

xii. **The campus site:** IUBAT is located in Sector 10, Uttara Model Town, Dhaka on a 5.5 acre site near the international airport. The campus lies on the bank of the Turag River with a panoramic view. It is an excellent location for academic study. The site has enough space to enable students to engage in outdoor sports on the campus site and protects classrooms from street noise.

xiii. **Multicultural student body:** IUBAT has attempted to draw international students from beyond Bangladesh. This is difficult to achieve, but there has been success in particular departments.

xiv. **Accessibility and Affordability:** IUBAT has a long-term vision of graduating at least one student from each village/ward/mohall of Bangladesh. This goal is a symbol of IUBAT's commitment to quality education throughout Bangladesh (Miyan 2015). IUBAT has provision for supplementing the family resources of students through scholarships, bursaries, fee waivers, deferred payment schemes, campus jobs, student loans and the like. IUBAT has established an educational cooperative (Multipurpose Cooperative Society Ltd. (IMCSL). One of its objectives is to mobilize funds for educational loans and scholarships for IMCSL members and their dependents.

Findings of the Faculty Survey:

The findings of the faculty survey are reported below:

Class Monitoring System

All faculty members agreed that the present monitoring system is effective in assuring attendance.

Course Outline for Organizing Teaching

In assessing the course outline protocol, 63.3% found it useful in organizing teaching; 33.3% stated that it is effective; and 3.3% stated that it is not relevant in organizing teaching.

Course Instruction Survey (CIS) for Feedback to Faculty

Students are required to carry out a CIS on completion of a course in a semester. 73.3% of faculty agreed that the CIS is a useful mechanism to gather feedback from students; 23.3% disagreed with the concept of student feedback, and 3.3% stated that they are not sure. The faculty suggested several improvements: (i) students should be given guidelines for completing the CIS; (ii) the CIS questionnaire should use plain, simple wording; (iv) some additional course attributes may be incorporated in the CIS questionnaire in line with evaluations conducted by other universities.

Learning Assessment Process

In assessing student learning, faculty choose from many options (e.g., student presentations, quizzes, assignments, project work, exercises, term papers, case analyses). 93.3% are satisfied with their learning assessment choices, while 3.3% stated that they are not satisfied, and 3.3% stated that they are not sure.

Faculty suggested several potential improvements in learning assessment: (i) classes should be more participatory, (ii) at least 10 minutes of class time should be spent on feedback to improve spoken English capability of students, (iii) extra learning sessions should be provided for weaker students; (iv) quiz systems should avoid using pen and paper and chalk board, (v) increased use of laboratory facilities for performing experiments, and (vi) introduction of open book examination.

Fair Examination in IUBAT

Exam cheating is unfortunately a widespread feature in Bangladesh universities. 80% of the faculty reported that the examination system in IUBAT is fair, while 6.7% think it doubtful; the remaining 13.3% are not sure.

Quality of Teaching Faculty

54% of the faculty are satisfied with the quality of their colleagues at IUBAT; 12% are not satisfied, and 34% refrained from making any comment. As to the suggestions for improvement, the respondents observed that (i) faculty should be recruited on the basis of merit, depth of subject related knowledge, experience, expressiveness and self-motivation; (ii) there should be a recruitment committee for each appointment; (iii) but the time required in the faculty recruitment process should be shortened, and (iv) there should be a separate human resources section in the university.

Teaching Aids in Classroom

90% of the faculty stated that the teaching aids in classrooms are adequate while 7% stated these to be not adequate; 3% did not respond. All classrooms at IUBAT are equipped with internet access, multimedia projectors, sound system, and white board with marker pens.

Library Resources of IUBAT

50% of the faculty stated that library resources are adequate, while 40% stated not adequate; 10% did not make any comment. Suggestions for improvement of library facility included (i) more space for reading materials and CDs; (ii) expansion of e-library access, and (iii) procurement of books through consultation with the concerned course instructor.

Registry Service

16.7% of the faculty stated that registry service is adequate while 63.3% stated that it is inadequate, and 20% did not make any comment.

Faculty Consultation Service to Students

Each course instructor is required to provide consultation hours every week for students in the course. 56% of faculty stated that the consultation service faculty provide is adequate, while 13.3% said not adequate; 30% are not sure. Suggested improvements included (i) desirability of friendly behavior for learning; (ii) new students are too dependent on the Program Coordinator and and they should be encouraged to seek advice from individual faculty, and (iii) students should be encouraged to consult with their class instructors.

Overall Quality Standard

On the question of overall quality, 64% of the faculty stated that IUBAT fulfils overall quality standards, while 36% disagreed. Some suggested that class size should be reduced.

Findings of the Student Survey:

Personal Study for each class Hour

To achieve quality education, students need to devote adequate hours to study. According to IUBAT regulations, students should back up every class hour by a minimum of three hours of personal study (Ref: IUBAT Bulletin). Most students are not meeting this expectation. 21% of the students reported undertaking backup personal study of less than one hour, 35% for one hour, and 44% for more than one hour.

Meeting deadline for submission of assignment/project

Assignments and project work are important in achieving learning goals. 84% of students submit project assignments on time; 16% fail to meet deadlines.

Perception on Dress and Behavior Code

The IUBAT mission calls for the "holistic development of the person" through the combination of academic and extra-academic activities, as well as personal development and grooming for a professional career. To encourage preparation for a professional career, IUBAT has adopted a dress code guideline for both male and female students. 69% of students found

the dress code very useful; 28% classified it as useful, and 3% did not perceive it as important in career development. On the question of following the dress code in the university, 100% said that they did so.

Fair Examination Process

74% of students expressed the view that the examination system prevailing is fair; 8% view it as unfair, and the remaining 18% refrained from making any comments. Asked whether they received exam results and scripts on time (within a week of writing the exam), 52% reported that they did; 44% reported this was not always the case, and 4% said they did not receive results on time.

Practice of English as a Medium of Instruction

IUBAT policy requires that every graduate demonstrate competence in reading, writing and speaking in English in academic and other contexts. To meet this requirement each student is required to pass with a minimum C grade three sequential courses intended to improve English writing and reading ability. All non-engineering students are required to pass a fourth class, public speaking in English.

Asked whether they use English as a medium of conversation, 90% replied affirmatively, 4% negatively, and 3% did not express any view. On the question of how they practise English, 66% reported that they practise through talking with teachers, friends, classmates; they make class presentations, attend debate competitions, undertake class room practice, group study, and watch English-language movies. 28% did not make any comment, and 6% reported difficulty in practising English. The challenges mentioned include (i) difficulty of keeping up a conversation in English with friends; (ii) limited number of friends available with whom to practise English; (iii) feeling shy due to poor speaking ability in English, and (iv) a de-motivational situation created by teachers who speak English in class but speak Bangla outside the class room.

Class Attendance

IUBAT policy requires students to attend all classes and laboratories. A maximum of three absences in a course is allowed with a valid reason. Unexcused absences lead to reduced course grade, suspension, or dismissal from the course. The survey on regular attendance suggests that 95% of students attend classes regularly, while 5% fail to do so. Two students cited personal engagements and traffic jams as reasons for poor attendance.

Use of Library Facilities by Students

85% of students said that they do visit the library (number of visits varies from a maximum of every day to a minimum of 10 days a month); however, 15% of students do not visit the library at all.

Can students follow the instructor's lecture?

100% of the students reported that they can follow the lectures and discussions in class. However, students made many suggestions on how the instructor could make the class more interesting (see Table 1).

Participation in Sports

IUBAT has a playing ground available for students to play games like football and cricket. There is also an indoor sports room where students play table tennis, carom board, etc. Sports competitions are organized regularly. 55% of the students reported that they do participate in games; 45% do not participate. The students who do not participate in games or sports reported the following reasons for inactivity (see Table 2):

Overall Quality Assessment by Students

On the issue of overall quality at IUBAT, 69% of the students reported it as good; 28% reported negatively; 3% abstained from making any comment.

Findings of the Alumni Survey

Unfortunately, only 28 alumni responses were found to be valid. The limited results are presented below:

What was the most useful learning experience at IUBAT?

This question elicited a mixed response. For the overwhelming majority, nearly 86%, the learning of English was the most useful learning experience at IUBAT. This was followed by adapting to a dress code, mentioned by 32%, and valuing the teaching methods, mentioned by 14%. Other comments included commitment of teachers and library use.

Contribution to Career Development

The alumni were asked to assess the contribution of IUBAT to their career development. Everyone responded positively on this question. 70% found their IUBAT experience "most effective", while 30% found it to be "moderately effective" to their career development.

Assessment of Learning Experience

In assessing the IUBAT learning experience, all responded positively. 37% found the learning situation excellent, while 63% found it satisfactory.

Utility of IUBAT Dress and Behavior Code in practical Life

93% found the dress code "very effective" in their professional life; the remaining 7% did not find it useful.

Assessment of Quality Standard

The alumni were asked their assessment of the quality standard in their respective IUBAT educational program. Most responded positively to this question: 67% reported that IUBAT maintains good standards, while 33% felt otherwise.

Overall quality standard Assessment by Different Stakeholders

In order to depict the overall quality of IUBAT as a university, a common question was asked to the stakeholders (faculty, students and alumni). The overall stakeholder assessment of quality is quite high with variations among the three groups (see Figure 1.)

Conclusion

Quality assessment is crucial to the development of higher education in any country. Surveys are not the only means to measure quality, but they are a valuable tool. The assessment conducted at IUBAT indicates considerable success in providing quality educational and related services. There is obviously more to be done. Striving to achieve quality is a continuous activity and requires collective efforts by all stakeholders. Creation of a "knowledge culture" is a big challenge for all universities more so in a developing society. The competition among these universities for students, particularly among the NGUs, forces them to be market-relevant. The value of this case study is to illustrate the range of policies required to achieve reasonable quality. We recommend that quality studies be carried out more widely among Bangladesh universities and robust quality assessment measures become widespread.

Table 1: Students' Remarks on Delivery Improvement

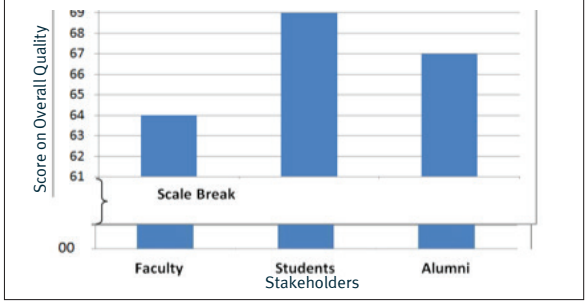
Suggestion to instructor	# of respondents
Provide an option for discussion on an issue	2
Be friendly in demeanor	8
Explain ideas directly to the class rather than read from the text or multimedia slides	1
Provide more practical examples in the class	9
Do not speak quickly	1
Maintain fewer than 50 students in the class	1

N=25

Table 2: Reasons reported by students for Low Participation in Games and Sports

Reason	No of Students
Too busy with study	19
No separate sports facility for women	1
Not interested in games/sports	7
Do not get any scope to play	5
Lost interest due to failure to win prizes in earlier events	2

Figure 1: Comperision of Quality Perception by Different Stakeholders



References

Green, D. (1994). 'What is quality in higher education? concepts, policy and practice', in Green, D. (Ed.), 1994, What is quality in higher education (Buckingham, SRHE/OU Press)

Harvey L and Green D (1993). Defining Quality, Assessment and evaluation in higher education

Knowles, M. (1975). Self-Directed Learning. Chicago: Follet.

Knowles, M. (1984a). Andragogy in Action. San Francisco: Jossey-Bass.

Knowles, M. (1984b). The Adult Learner: A Neglected Species (3rd Ed.). Houston: Gulf Publishing.

Miyan, M Alimullah (1993). Proposal for Establishing the University of Business Agriculture and Business at Dhaka, Bangladesh. Available from authors on request.

Miyan, M Alimullah (2011). Critical Role of Higher Education in National Development, APUB Roundtable. VIP Lounge of National Press Club, Dhaka, Bangladesh

Miyan, M Alimullah (2011). Challenge of Intellectual Capital Development through Higher Education, IICM 2011, Zanjan, Iran

Miyan, M. Alimullah (2015). Knowledge Based Area Development: A Step towards Community Self-Reliance. IUBAT.

Professional Support and Curriculum Directorate (2003). Quality Teaching in New South Wels (NSW) Public Schools

Scott, P. (1994). 'Recent developments in quality assessment in GB', in Westerheijden, D.F., Brennan, J., and Maasen, P. (Eds.), Changing contexts of quality assessment: recent trends in West European higher education (Netherlands, CHEPS).

UNESCO (1995). Policy Paper for Change and Development in Higher Education

Westerheijden, D.F. (1999). 'Where are the quantum jumps in quality assurance? development of a decade of research on a heavy particle', Higher education

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Monetary Policy and Equity Return: Evidence from the US Markets

Mozaffar Alam Chowdhury
Finance College of Business Administration
IUBAT—International University of Business Agriculture and Technology
Uttara,1230

ABSTRACT: *This paper investigates the relationship between interest rate changes and equity returns during crisis periods following the "dot com" bubble burst (1999-2001) and the Lehman Brothers collapse (2008). Several relevant macroeconomic variables have been considered for forecasting – using a time series model, a vector autoregressive model and impulse response functions, including variance decomposition of fluctuations in equity prices. The data are from the Federal Reserve data sets, 1999 to 2016.The results indicate a significant change in the nature of the stock market response to monetary policy action in August 2007. The monetary policy makers failed to boost the stock market during the crisis periods.*

KEYWORDS: *Monetary Policy, Shock, Equity Return, Vector Autoregressive, and Impulse Responses.*

Introduction

Monetary policy objectives include macroeconomic variables such as real GDP growth, inflation and interest rates. When central banks change monetary policy, they affect macroeconomic variables indirectly. Stock prices are highly sensitive to economic news and are closely monitored. In this study, I have examined the impact of anticipated and unanticipated monetary policy actions taken by the Federal Reserve Bank on US equity returns. I define the unanticipated impact of monetary policy as the change in the three-month London Interbank Offered Rate (LIBOR). Futures contracts reflect market expectations at a given time. If the central bank undertakes a policy shift that the market expects, there should be no subsequent change in futures contracts. If, on the other hand, a change arises subsequent to a central bank policy change, that suggests an unexpected shift. While LIBOR is a London-based instrument, international financial markets are sufficiently integrated, that it has an indirect impact on short term interest rates in the US market. In summary, the prices of futures contracts on short term interest rates are a common measure used by the central bank; they help central bankers to forecast expectation and see the difference between futures rates and realized rates for monetary policy decisions.

The time period considered is from January 1999 to December 2016. A time series model has been estimated to forecast equity returns; a vector autoregressive model (VAR) has been estimated to forecast macroeconomic variables and show the relationships among them; finally, impulse responses have been estimated to measure the effect when a positive one standard deviation shock is given to specific variables. The purpose of the study is to investigate the relationship between monetary policy action and equity returns (S&P 500 index). The study has investigated the structural break in the relationship between interest rate changes and equity returns during the crisis periods. The results indicate a significant change in the nature of the stock market response to monetary policy shifts since August 2007. The paper also describes the stock market data, calculation of the monetary policy shock, empirical models and results.

Review of the Literature

Extensive research has been conducted to show the relationship between monetary policy and stock returns. Monetary economists are concerned with whether an unexpected change in monetary policy, reflected in the change in the three-month sterling LIBOR futures contract, has any effect on stock prices (Gregoriou et al 2009). On the other hand, financial economists are concerned with whether equity is a hedge against inflation. Bernanke and Gertler (2001) considered stock price "bubble" shocks and they found that an aggressive inflation-targeting rule stabilizes output and inflation when asset prices are volatile. Thorbeke (1997) applied a vector autoregression (VAR) model to examine the effects of monetary policy shocks on stock returns. Bernanke and Kuttner (2005) pointed out that the link between monetary policy changes and stock returns should account for anticipated policy actions. Estimating the response of equity prices to monetary

policy actions is not easy, as the market is unlikely to respond to policy actions that have already been anticipated, and distinguishing between expected and unexpected policy actions is essential for discerning their effects (Bernanke and Kuttner, 2003).

The relationship between monetary policy and stock returns has been measured in a variety of ways. VAR models examine the effect of monetary policy on stock returns; impulse response functions and variance decompositions from a VAR reveal statistically significant relationships between monetary policy and stock returns, with either a positive shock to the fed funds rate or negative shock to stock returns.

Distinguishing between expected and unexpected policy actions is essential. A simple way to do this is the methodology proposed by Kuttner (2001), which used Fed funds futures data to construct a measure of "surprise" rate changes. Bernanke and Kuttner (2005) used Kuttner's (2001) futures methodology to decompose the federal funds rate changes into expected and unexpected monetary policy shocks and found that an unanticipated monetary policy had a negative impact on the US stock market.

Data, Methodology and Choice Variables

The sample period covers 1999:Q1 to 2016:Q4. Data are collected from the Fred and Yahoo Finance. The equity returns data include S&P 500 index returns. I have measured equity returns by taking daily closing stock prices. This study examines a five-variable VAR that includes world oil prices, real GDP, the inflation rate, a measure of monetary policy estimated by the first difference of the fed funds rate and real stock returns. The software Stata and Eviews have been used to analyze data in time series models, VAR model, IRFs and variance decomposition.

Modeling Strategy

The equity returns are measured as the first difference of the natural log of the daily closing prices of the S&P 500 Index. Following Kuttner (2001), I have used data from the Fed funds rate in order to derive the monetary policy shock. The proxy for the unanticipated effect of a monetary policy shock, Δi_t^u, is the change in successive quarterly dollar LIBOR (London Interbank Offered Rate) futures contracts:

$\Delta it^u = LIBOR_t - LIBOR_{t-1}$

I have measured the expected change in interest rates, Δi_t^e, as the actual change in the three-month Fed funds rate minus the surprise:

$\Delta i_t^e = \Delta i_t - \Delta i_t^u$

The change in equity return is estimated as the first difference of the natural log of the quarterly closing price of the S&P 500 index:

Y_t (spindex_return) = 100*(lnspindext – $lnspindex_{t-1}$)

To examine the interactions among all economic variables and equity prices, the VAR is estimated using equity returns, interest rate (fed funds rate), inflation rate, real GDP, and oil prices. The impulse response functions and variance decompositions have been estimated from a vector autoregression that incorporates statistically significant relationships between monetary policy and stock returns. Based on

the estimated VAR, we can illustrate the projected impact of a one standard deviation positive shock to the fed funds rate or a negative one standard deviation shock to stock returns.

Time Series Models

The initial empirical investigation regresses S&P 500 returns on expected and unexpected interest rate changes.

Model 1

$$Y_t = \alpha + \beta^e \Delta i_t^e + \beta^u \Delta i_t^u + e_t$$

Where, α is the constant term/intercept

β^e is the parameter associated with expected monetary policy

β^u is the parameter associated with unexpected monetary policy

Δi_t^e is the parameter associated with expected interest rate change

Δi_t^u is the parameter associated with unexpected interest rate change

e_t is the parameter associated with error term

The OLS result in Table 1 indicates that the estimated stock market response to both the expected and unexpected components of monetary policy changes are statistically sig-

Table 1: Regression Output from Model 1, 2 and 3

	Model 1: Regression	Model 2: Regression	Model 3: Regression
Constant	1.167 (0.132)	1.785 (0.001)	
Δiexpect	8.704 (0.006)	2.318 (0.540)	-3.998 (0.541)
Δiunexpect	6.527 (0.001)	4.660 (0.013)	3.028 (0.134)
dummylehman		-11.980 (0.012)	-14.594 (0.000)
Dummy99_01		-6.520 (0.041)	-6.608 (0.020)
interactΔi expected			0.038 (0.100)
interactΔi unexpected			0.005 (0.059)
Observations	71	71	71
R2	0.187	0.294	0.430
R2 adjusted	0.163	0.251	0.378

nificant, but the adjusted R^2 statistic is small. This first specification has serial autocorrelation and heteroscedasticity problems. It does not adequately model the period that has large negative returns in the stock market, in 2002 (following the 'dot-com' bubble burst) and 2008 (right after the collapse of Lehman Brothers). I have re-specified in model 2, by including two dummy variables:

Model 2

$$Y = \alpha + \gamma_t \, DLehman_t + \gamma D2002_t + \beta^e \, \Delta i_t + \beta^u \, \Delta i_t + e_t$$

Where,

γ_t is the parameter associated with $DLehman_t$

γ_t is the parameter associated with $D2002_t$

[plus variables included in Model 1]

DLehman is equal to 1 during October-November 2008 and one period before and after; 0 otherwise. D2002 is equal to 1 in August 2002 and 0 otherwise. In table-2, the adjusted R^2 value (0.25) is larger than in model 1. Residuals are now free from heteroscedasticity and serial autocorrelation. The unexpected monetary policy variable is statistically significant, as are the two dummy variables, but the expected monetary policy variable is not significant.

I have considered the credit crisis on August 2007 onwards to 2009, where the equity market declined in valuation and interest rates declined too. Therefore, there is positive correlation between the stock return and interest rate changes. I wanted to know the change in this period due to expected and unexpected monetary policy changes. To do that, I have interacted the variables with crisis as dummy variable.

Model 3

$$Y = \alpha + \gamma_t \, DLehman_t + \gamma_t \, D2002_t + (\beta^e + \delta_t \, Dcrisis) \, \Delta i_t^e + (\beta^u + \delta_t \, Dcrisis) \, \Delta i_t^u + e_t$$

Where, α is the constant term/intercept

γ_t is the parameter associated with DLehmant

γ_t is the parameter associated with $D2002_t$

δ_t is the parameter associated with Dcrisist

Dcrisis is 1 from August 2007 to 2016; 0 earlier

β^e is the parameter associated with expected monetary policy

β^u is the parameter associated with unexpected monetary policy

Δi_t^e is the variable associated with expected interest rate change

Δi_t^u is the variable associated with unexpected interest rate change

e_t is the error term

In the above model, I have generated dummy variable Dcrisis equal to 1 from August 2007 onwards and 0 otherwise. This allows for a lagged effect of the Lehman collapse, post 2007.

Table 3 shows that the adjusted R^2 statistic has improved to 0.38, which tells us the fitness of the model improves on model 2. The unexpected monetary policy shock is positively associated with the stock returns but statistically is not significant. The expected monetary policy is negatively associated with the stock returns and statistically is not significant. The

two crisis variables are negatively associated with the stock returns and are highly significant. However, the dot com bubble burst and Lehman Brothers lagged dummy variables are related positively with the stock returns and are marginally significant at 0.1; the unexpected coefficient is significant at 0.1. This tells us that the stock market has not improved due to monetary policy changes following the post-2007 financial crisis, which means monetary policy makers have failed to boost up the stock market.

Estimation and Empirical Results

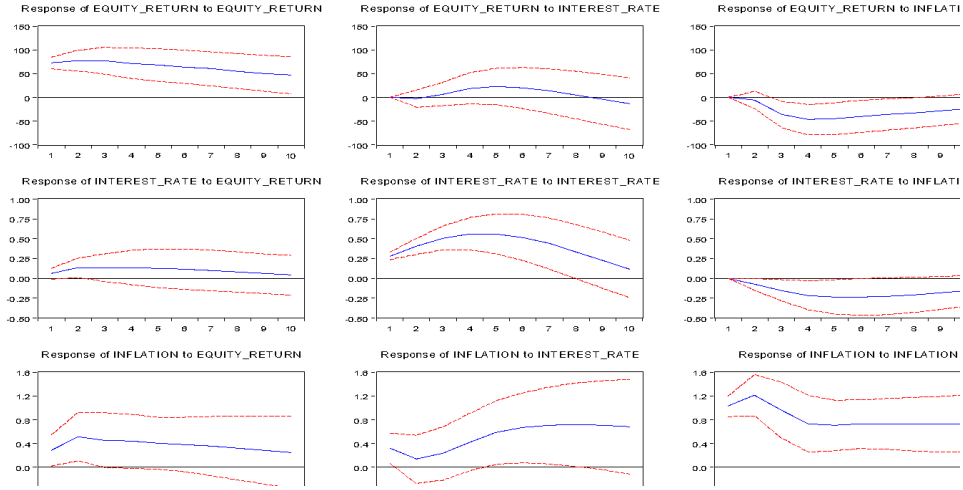
In this section, I have examined the monetary policy variable, stock returns, inflation rate, real GDP growth and oil prices. I run the impulse responses of stock returns to a positive one-standard-deviation shock to fed funds rate and variance decomposition analyzes forecast error to determine the monetary policy shock to the variance of stock returns.

The VAR and Impulse Response Functions (IRFs)

The model to run the VAR using the data describes above with an appropriate lag selection and IRFs includes real GDP, inflation, interest rate (fed funds rate), stock returns (S&P 500) and oil price (world) because it may influence monetary policy and, when oil price increases often indicates a pressure for future inflation. The Cholesky ordering for the model is: equity returns, real GDP, oil price, inflation, and interest rate (fed funds rate). While running VAR, the number of lag selection has been chosen based on the Akaika Information Criterion (AIC). An unrestricted VAR has been estimated, as the variables are not co-integrated. I have selected three lags based on AIC and for ordering the variables.

The responses of equity returns to various shocks from the macroeconomic variables are shown in Figure 1, which is a reduced form of impulses estimated from the VAR. The equity return has been affected by the interest rate shock in the short, medium and long run. This means when monetary policy tightens, the equity return decreases and vice-versa. An inflation shock causes significant fluctuations in equity returns. The equity returns are below the baseline and negative throughout the timeline and at the beginning, equity returns declines from the base line and then it follows steady but negative below the baseline. The shock from equity return leads to a marginal change in the equity prices in the medium and long run. The above findings suggest that the impact of interest rate shocks on equity return is significant and may be an interest to the central bank to respond to equity return indirectly. Impulse response results shows that the equity return is sensitive to monetary policy changes provide a strong evidence for developing monetary policy to control equity price movement.

Figure 1: Impulse responses to Cholesky one S.D. shocks



Variance Decomposition

The results of variance decomposition in equity prices caused by various macroeconomic variables shocks are presented in Table 2.

Table 2: Variance decomposition of fluctuation caused in equity prices

Variance Decomposition of EQUITY_RETURN:

Period	S.E.	EQUITY_R...	INTEREST...	INFLATION	REAL_GDP	OIL_PRICE
1	74.12717	100.0000	0.000000	0.000000	0.000000	0.000000
2	108.0964	99.18248	0.000441	0.116017	0.685449	0.015618
3	135.1226	94.97611	0.973728	3.522950	0.438710	0.088504
4	161.4368	86.83285	4.030953	7.046249	0.324924	1.765026
5	183.7827	80.61857	6.654573	9.115144	0.394281	3.217434
6	200.6254	77.30518	8.165051	10.16704	0.664442	3.698293
7	213.0478	76.09897	8.535741	10.63019	0.946068	3.789030
8	222.3179	76.20979	8.213844	10.68034	1.141487	3.754543
9	229.5230	76.92353	7.719362	10.47094	1.247605	3.638555
10	235.3831	77.63296	7.427275	10.14081	1.303130	3.495828

The interest rate tends to have a medium to long run impact on stock prices because there was no large variation in the first quarter but there was in the second and third quarters. The variance decomposition analysis of fluctuation in inflation reveals that equity prices are influenced in the short and medium term. Real GDP shocks influence the equity returns in the long run, and oil prices have a little impact on equity return in the short run.

Conclusion

This study investigates the impact of anticipated and unanticipated monetary policy of Federal Reserve monetary policy on US S&P 500 stock returns. The monetary policy shock is generated from the change in the three-month dollars LIBOR futures contract for a sample period from January 1999 to December 2016. Using time-series model, I have shown that both the expected and unexpected monetary policy changes affect significantly stock returns. The result shows an important change in the stock market reaction to monetary policy changes since 2007. This means that monetary policy makers failed to boost up the stock market valuations during the crisis period. The interaction between monetary policy shocks and stock returns has been shown with VAR analysis and Impulse Response Functions (IRFs). It is evident from the analysis that monetary policy variables affect equity returns during the crisis period and monetary policy actions have impacts on other macroeconomic variables in the short and medium run.

Reference

A. Gregoriou A, A. Kontonikas B, R. Macdonald B, A.Montagnoli, (2009). "Monetary Policy Shocks and Stock Returns: Evidence from the British Market". JEL

Bernanke, B. and K. Kuttner, (2003). "What Explains the Stock Market's Reaction to Federal Reserve Policy?" Journal of Finance.

Bernanke, Ben S. and Mark Gertler (2001), "Should Central Banks Respond to Movements in Asset Prices?" American Economic Review.

Bernanke, Ben S. and Kenneth N. Kuttner (2005). "What explains the Stock Market's Reaction to Federal Reserve Policy?"Journal of Finance.

Kuttner, K., (2001). "Monetary Policy Surprises and Interest Rates: Evidence from the Fed Funds/Futures Market", Journal of Monetary Economics.

Willem Thorbecke (1997). "On Stock Market Return and Monetary Policy". The Journal of Finance.

Federal Reserve Economic Data at https://fred.stlouisfed.org/ accessed on 4/15/2017.

Yahoo Finance at https://finance.yahoo.com/ accessed on 4/15/2017.

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Improvement of Livelihood through Diversified Income Generation

Abdul Jabber,
Department of Economics
IUBAT – International University of Business Agriculture and Technology
Uttara, 1230

Selina Nargis
Department of Psychology,
IUBAT – International University of Business Agriculture and Technology
Uttara, 1230

Muhammad Shahjahan
Economics Department
IUBAT – International University Of Business Agriculture and Technology
Uttara, 1230

ABSTRACT: *This paper evaluates existing modern rice technology adoption and the possibility of increasing household income of resource-poor farms under three diversified production environments in Bangladesh. The potential expansion of modern rice technology has nearly been exhausted in areas displaying favorable production environments. In these areas, there remains scope for enhancing household income through non-rice crop production. On the other hand, the prospect for increased productivity seems elusive in the tidal wetland areas unless flood-resistant rice varieties can be developed and adopted. The output in flood-prone areas devoted to Modern Variety (MV) rice cultivation in the Transplanted Aman (T. Aman) season is 35%, against the national average of 60%. To cultivate a larger area under a flood-prone environment, alternative crops such as vegetables may be cultivated immediately after the recession of flood water. About 38% of the cropped land in drought-prone areas is devoted to MV T. Aman season rice cultivation. Low diffusion of modern technology, caused by infrastructural backwardness, is a prominent barrier to higher agricultural income generation for farms in drought-prone areas of Bangladesh.*

KEYWORDS: *Economics, rice technology, agriculture, income , productivity, livelihood, crop cultivation, development, environment, floods, drought*

Introduction

The importance of rice as source of income of farming households in Bangladesh can hardly be overestimated (Elias, 2000). Agriculture diversification and rice-based income are always important to all the marginal and small farm households of the country (Brahmmer, 1977). It is agreed among agricultural experts that the principal constraints to increasing rice-based income is inadequate knowledge in relation to two questions; (i) for which sub-groups of households is income from rice-related activities especially important; and (ii) how best to assist and enhance the income from such activities among poor households. The context to this analysis is the rapid diversification of agricultural activities (Orr and Magor, 1992).

In order to understand the assets and livelihood strategies of target groups, their coping strategies and cultivation practices should be analyzed. This article analyzes the livelihood strategies of resource-poor households within and beyond rice-based activities in three different production environments: flood-prone, drought-prone, and environments with favorable rice production conditions (Hussain et al., 1999). It attempts to provide policy guidelines to enhance productivity and income generation among resource-poor households. The specific objective of the study is to (i) examine the pattern of income earnings against source; (ii) examine the influence of different asset-based factors on income generation of these farming households; and (iii) evaluate the related factors for enhancing output to reduce poverty of the resource-poor farmers.

Methodology

Data for this study were collected from three environments favorable, flood- and drought-prone). Bogra district was taken as a favorable production environment, while Kurigram and Rajshahi districts have been treated as flood and drought-prone environments respectively. One upazila from each district was selected, and from each selected upazila one union was selected. Two villages from each union were randomly selected. As first step, a list of farmer from each village was prepared. Sample farms from each village were selected following the wealth ranking procedure. From each village 50 farms were selected, in total100 farms from each of the three environments. Farm households in a village were divided into four categories: large, medium, small and vulnerable groups (marginal farmers).

Analytical Tool

Tabular analysis is followed by analyzing the data related to sources of income and rice production technology. The asset base factors have been divided into five categories: (i) Natural capital (natural resource stocks able to generate resource flows); (ii) Social capital (social networks, memberships, access to wider institutions upon which people draw); (iii) Human capital (skills, knowledge, and ability plus good health); (iv) Physical capital (basic infrastructure and production equipment); and (v) Financial capital (total income received as saving and remittance) (Reordan, 1997).

In order to estimate the relationship between net income and asset-based factors the

Corresponding Author: Md Abdul Jabber, dr.jabber@iubat.edu

following multiple linear regression model has been used.

$y_i = \alpha + \Sigma ß_i x_i + u_i$

Where,

y_i = Net income in Taka per household i = 1 … 300

x_1= Human capital. It is measured by scoring the education level and technical knowledge). For no education scoring is zero. Otherwise scoring is measured on the basis of years of schooling. Technical knowledge is considered as dummy variable = 1, if farmer has technical knowledge, otherwise it is zero.

x_2 = Natural capital. A farmer having all these resources, namely owned land, domestic animals, and irrigation facilities, scores 100. In the case of two or one resource, the score is 66 or 33 respectively.

x_3= Physical capital. Agricultural tools and availability of electricity are measured by dummy variables. If available value is 1; otherwise it is zero.

x_4= Financial capital. It is measured by actual amount of money available from savings, gift and remittance.

x_5= Social capital. It is measured by scoring the number of memberships in any social institution including service as village leader.

α = intercept

u_i= disturbance term

Results and Discussion

Annual income distribution pattern of the resource-poor households

The annual income distribution of resource-poor farm households in three different environments of Bangladesh is presented in Table 1. It is evident

Table 1: Average annual income (Taka) of farm households in three environments of Bangladesh, by income source 2015

Sources of income	Environment		
	Favourable	Flood-prone	Drought-prone
On-farm income	32670 (30.53)	12027 (27.51)	19383 (19.72)
Off- farm income	18350 (17.15)	13941 (31.88)	73830 (75.16)
Non-farm income	56000 (52.32)	17754 (40.61)	5030 (5.12)
Grand total	107020 (100)	43,722 (100)	98244 (100)

Note: Figure in the parentheses indicate percentage of total

On-farm income = Cereals crops, vegetables, spices and others

Off- farm income = Fisheries, livestock, day labor and daily workers in different operations

Non- farm income = Business, service (public, non-Government, remittance, and services at different transport sector)

Source: Survey Data, 2015

that annual income per farm household was the highest (Tk. 107,020) in favorable production environment followed by drought-prone environment (Tk. 98,244) and flood-prone environment (Tk. 43,702). The average income of the farm households at flood-prone environment was extremely low and it was only two-fifth of favorable production environment. The probable reason for low income in flood-prone environment was low productivity of crops due to hazards in cultivating crop in water logging and poor crop management practices. This can be improved through adaption of flood resistant variety or cultivation of high yielding alternative crop variety.

In the flood-prone environment, the non-farm income source was the most important (41%). Among the on-farm income sources, rice was the main source of income, almost 60 percent of the total on-farm income. A different picture appeared in the drought-prone environment: off-farm sources of income contributed by far the highest share (75%). Among the off-farm income sources, livestock production was the highest (81 percent). The high income from this source was due to low cost of production in livestock. Raising livestock is an established agricultural sector. Small investments can generate robust income. Income from rice and vegetables was very low in this area because farmers fear drought. In the favorable environment (Bogra), non-farm income was the main source of income generation (52%), followed by on-farm income source (31%). The high share of income from non-farm sources is due to foreign remittance. Among the on-farm sources, vegetable production was the main source (59%). The share of rice to total on-farm revenue was 35 percent. Though the rice share of on-farm income was low, the income from rice was still higher (Tk.12,000) compared to the other two environments. The main causes were higher rate of MV adoption in the favorable environment compared to the two other environments.

Determinants of net income

The influence of different asset-based factors on farmers' net earnings was evaluated using regression analysis and the corresponding result are given in Table 2. The asset-based factors are financial, natural, social, physical and human capital at different environments. The independent variables were taken considering the weighted average value of each factor. The co-efficient of natural capital were positive and significant (at 10% level) for all the locations. This indicated that net income of the sample farm households increased through natural capital.

In the favorable production environment, the co-efficient of financial capital was 8655 (significant at 5% level) implying that the income would increase by Tk. 8655 due to increase of 1 weight of financial capital. This shows that financial capital has a very important impact on net income generation in this environment, because most of the households received foreign remittances on a regular basis and actual amount of saving from agricultural sector. The impact of financial is so high in favorable production environment it influenced other two environments too. That is why financial capital projected significant result in all regions. As a result $R^2 = 0.70$ due to high impact of financial capital.

Table 2: Association of Average annual income (Taka) of farm households with Asset-based Factors under different environment environments, 2015

Variables	Coefficients			
	Favourable production	Flood-prone	Drought-prone	All regions
Financial capital	8655**	1807	8998	16778**
	(4018)	(2030)	(6200)	(2818)
Natural capital	3396*	822*	3537*	2522*
	(1843)	(530)	(1743)	(1208)
Social capital	3356	300	686	90
	(4885)	(261)	(975)	(683)
Physical capital	15620	3861	6420*	3689
	(9860)	(2121)	(3607)	(2285)
Human capital	7393*	161	388	6778
	(4124)	(889)	(3056)	(3780)
Number of observations	100	100	100	300
R^2	0.77	0.49	0.68	0.70
Adjusted R^2	0.76	0.48	0.66	0.69

Figures in the parentheses indicate standard error.

** Significant at 5% level. * Significant at 10* level.

Source: Survey Data, 2015

In the drought-prone environment, the co-efficient of physical capital was 6420 (significant at 10% level), which implies that the contribution of physical capital has substantive impact on net income generation.

The adjusted coefficients of determination for favorable, flood-prone and drought-prone environments are 0.76, 0.48 and 0.66 respectively, overall 0.69.

Area devoted to rice production and its impact on income generation

Over the period 1971/72 to 2015/16, the Aus rice area declined at an annual rate of 4.12 percent. The growth rate was positive (but not substantial) during the 1970s. Beginning in the 1980s, the total Aus rice area declined (see Table 3). The possible reason could be the shifting of Aus rice areas into Boro rice. Moreover, the expansion of irrigation facilitated the remarkable growth of the Boro area. In the Boro season (winter), irrigation constitutes a major cost, which the resource-poor farmers cannot afford.

The cost analysis showed that the benefit cost ratio in T. Aman season is higher compared to other two seasons (Boro and Aus) in all environments (Table 4). Therefore, the only option remains for the resource-poor farmers is to increase rice production through increasing production per unit area and expanding of the MV T. Aman area.

Table 3: Estimates of annual growth rates of area under rice in Bangladesh, 1971-2015				
Growth	Aus (summer harvest)	Aman (autumn harvest)	Boro (spring harvest)	Total rice
1971-72 to 2015-16	-4.12	-0.02	6.12	0.25
1971-72 to 1980-81	0.45	0.90	2.00	0.96
1981-82 to 1990-91	-4.58	-0.96	9.10	-0.12
1991-92 to 1999-00	-3.98	-0.35	6.12	0.48
2000-2001 to 2008-2009	-3.99	-0.40	2.16	-0.38
2009-2010 to 2015-2016	-3.75	-0.48	8.01	1.68

Source: Handbook of Agriculture Statistics (2015), Ministry of Planning.

Table 4: Cost-benefit analysis of modern rice cultivation (Takas/hectare), 2015									
Items	Favourable production			Flood-prone			Drought-prone		
	Boro	Aus	T. Aman	Boro	Aus	T. Aman	Boro	Aus	T. Aman
Variable cost	71000	55200	60070	60000	49020	51000	55000	50100	50000
Fixed cost	180	110	160	150	118	148	160	130	135
Total cost of production	71180	55310	60230	60150	49138	51148	55160	50230	50135
Grain yield	5520	3580	4500	4800	3000	3900	4000	2900	3500
Gross return	99360	64440	85500	81600	54000	70200	70000	52200	65000
Net returns	28180	9136	25270	21450	4862	19052	14840	1970	14865
Benefit-cost ratio	1.40	1.12	1.42	1.36	1.10	1.37	1.27	1.04	1.30

*Land cost not included, ** Includes straw cost.

Source: Survey Data, 2015

Enhancement in MV adoption to national level

The present share of cultivable land devoted to MV T. Aman in the drought-prone environment is only 38 percent. It is 60 percent at the national level. If farmers in the drought-prone environment could realize the national share of land devoted to MV T. Aman rice, then on average each farm would be able to obtain an additional 20.65 kg of rice. By a similar calculation, the farmers in the flood-prone environment could get an additional production of 115.02 kg per household (Table 5).

Table 5: Projected increase in production of T. Aman through enhancing areas under MV cultivation, 2015

Average area under T. Aman (per household) (Decimal)	MV area c. (Decimal)	Reduction in LV area d. (Decimal)	Reduction in LV production (Kilogram)	MV production (Kilogram)	Increase in MV production (Kilogram)	Net increase in rice production (Kilogram)
1.	2.	3	4.	5.	6.	7. (= 6.–4.)
	Flood-prone					
0.81 (x 0.35) a.	0.283	-	-	446.66	-	-
0.81 (x 0.60) b.	0.486	0.203	205.38	767.06	320.40	115.02
	Drought-prone					
0.84 (x 0.38) a.	0.319	-	-	387.29	-	-
0.84 (x 0.60) b.	0.504	0.252	203.96	611.90	224.61	20.65
	Favourable					
0.75 (x 0.89) a.	0.667	-	-	966.35	-	-

Notes:

environment-specific level of MV adoption,

National level of MV adoption

MV: modern variety of rice

LV: local variety of rice

In drought-prone environment MV and LV rice are 3000 kg/ha and 2000 kg/ha respectively.

In flood-prone environment MV and LV are 3900 kg/ha and 2500 kg/ha respectively.

In favorable area production, is 4500 kg/ha.

Figures in the parentheses indicate % of MV adoption.

In the favorable production environment, the rate of MV T. Aman adoption is much higher than the national level, because of favorable production environment and intensive utilization of land. So, there is no scope of increasing area under MV T. Aman area in this environment.

Previously, in the three seasons (Boro – Aus – T. Aman) the crop pattern was MV-LV-LV. Now, the prevailing present pattern is MV-MV-MV (Table 6).

Table 6: Past & present cropping pattern in favorable production environment, 2015

Previous cropping pattern % area covered (percent share)		Present cropping pattern % area covered (percent share)	
Boro-Aus-Aman MV – LV – LV	55	Boro-T.Aus-T.Aman MV – MV - MV	45
Potato-Jute-Aman	25	Potato-Boro-Vegetable	38
Rabi crops-Jute-Aman	10	Potato-Boro-T. Aus-T.Aman	5
Vegetable-Sugracane	2	Potato-Boro-Veg.-Veg.	8
Fallow-Aus-Aman	8	Veg.-Boro-T. Aus-T.Aman	4

Source: Survey Data, 2015

Famers' opinion on MV rice adoption

The farmers' perceptions about the problems and constraints with respect to MV adoption, in both drought-prone and flood-prone environments, are shown in Table 7. Among all problems mentioned by the sampled farmers, the absence of a demonstration program ranked first in both the areas. The second most important problem was lack of extension contact. The other problems were lack of irrigation facilities, non-availability of fertilizer and insecticides. These problems could be minimized if Direction of Agriculture (DAE), Bangladesh Agriculture Development Corporation (BADC) and Non-government Organization (NGOs) could provide assistance. Farmers' opinion on their desired assistance are presented in Table 8. Supply of good quality seeds got the highest priority among the needed assistance as desired by majority of the sample farmers in both the areas.

Table 7: Problems and constraints with respect to expansion of MV rice varieties in flood and drought-prone environments, 2015

Problems/ Constraints	Drought-prone		Flood-prone	
	Percentage of farmers response	Rank	Percentage of farmers response	Rank
Absence of demonstration program	90	1st	88	1st
Lack of extension contact	86	2nd	76	2nd
Lack of quality modern seeds	82	3rd	68	3rd
High price of input	73	4th	61	4th
Lack of Irrigation facility	68	5th	59	5th
Insect and disease infestation	38	6th	35	7th
Lack of fertilizer and insecticides	32	7th	21	8th
Environmental degradation	28	8th	50	6th

Source: Survey Data, 2015

Table 8: Farmers views about desired assistance for increasing household income, 2015

Desired assistance (s)	Percent of farmers respondent	
	Flood-prone	Drought-prone
Supply good quality seeds	96	85
Supply credit	75	38
Preventive measure for resisting betel leaf diseases	42	40
Supply good quality fertilizer and insecticides	36	25
Provide training to farmer	26	48
Increase irrigation facilities	12	9
Make necessary arrangement for testing the soil	2	6

Source: Survey Data, 2015

Increase in production through increasing yield

A second option for increasing income is to increase yield (see Table 9). For example, the present average MV T. Aman yield in the drought-prone environment is 3.00 tonne/ha. With proper management farmers could achieve at least 4.00 t/ha in T. Aman season, equivalent to an additional 149.77 kg per household. Similarly, farmers in the flood-prone environment could get an additional production of 269.11 kg per household.

Table 9: Estimated incease in production of T. Aman through increasing the yield (4.00 ton/ha), 2015

Average area under T. Aman (per households) (Decimal)	MV area (Decimal)	Reduction in LV area (Decimal)	Reduction in LV production (Kilogram)	MV production (Kilogram)	Increase MV production (Kilogram)	Net increase in rice production (Kilogram)
1.	2.	3	4.	5.	6.	7. (= 6.–4.)
Flood-prone environment						
0.81 (x 0.35)	0.283	-	-	312.55	-	-
0.81 (x0.60)	0.486	0.203	205.38	787.00	474.49	269.11
Drought-prone environment						
0.84 (x 0.38)	0.319	-	-	516.39	-	-
0.84 (x0.60)	0.504	0.185	149.73	815.86	299.47	149.77
Favorable environment						
0.75 (x 0.89	0.667	-	-	1215.18	-	-

See notes to Table 5.

On the other hand, the average yield of MV T. Aman rice in the favorable production environment was 4.50 t/ha, higher than the national average yield (3.00 t/ha). Farmers in the favorable production environment get an additional yield of 1.50 t/ha relative to the national average. The explanation is the higher diffusion of modern technologies. So, in the favorable production environment, there is little scope for reducing poverty through increasing MV adoption unless high yield potential varieties are introduced. The area under vegetable production in the favorable production environment is much higher than the national average. Another option for reducing poverty may be to increase vegetable production by supplying quality seeds.

The relative price index of crops and agriculture inputs over the period (1972-73 as the base year) shows that the relative price index for vegetables rose sharply in real terms to 322, a much greater increase than for other crops (see Table 10). If this trend continues, vegetable production in Bangladesh may have enormous scope for raising farm household net income, and could help to reduce poverty in all environments.

Table 10: Relative price index of crops and agricultural inputs, 1972/73 to 2013/14

Inputs/Output	Growth rate* (% per annum)	Index (1972-73 = 100)	Current price index (2013-2014)	Real price index, adjusted for inflation (1972-73=100)
Diesel	38	100	2380	595
Agricultural wages	23	100	580	145
Fertilizer	20	100	510	132
Insecticides	11	100	533	128
Cereals	10	100	401	90
Rice	10	100	452	118
Pulses	9	100	455	98
Mustard & oil seed	16	100	330	68
Jute	8	100	601	115
Sugarcane	15	100	448	97
Tobacco	6	100	360	69
Potato	5	100	342	58
Spices	18	100	515	110
Vegetables	24	100	1500	322

*Estimated by semi-log function fitted to least square trend line.

Source: Price information collected from Bangladesh Bureau of Statistics (Dhaka various years)

Conclusion

Household incomes in the drought-prone and flood-prone environments are extremely low compared to incomes in the favorable production environment. In the drought-prone environment the lion's share of income is generated from livestock production; the contribution of rice to the total income is low. In the flood-prone environment, income from the non-farm sources is the most important, and rice contributed a considerable share. In the favorable production environment, the adoption of MV T. Aman rice was above the national

average and the area under vegetable production was also high. But in drought-prone and flood-prone environments, the adoption of MV in T. Aman season was low compared to the national average. Lack of extension contact and inadequate supply of good quality MV seeds were the main causes for low MV adoption and yield in this area.

In the drought-prone and flood-prone environments there is potential to increase production in T. Aman season by increasing the level of MV adoption, which would be ultimately helpful in reducing poverty. On the other hand, increased cultivation of vegetables would help reduce poverty in these environments.

Financial capital plays a vital role on net income generation in the favorable area. Foreign remittances are the major source of financial capital. In all the environments increases in natural capital cause a substantial increase in net income. A different picture appears in drought- prone areas where physical capital development enables the households to realize additional income.

Recommendations

There is scope for increasing the rate of MV adoption and yield in T. Aman season, both in the drought-prone and flood-prone environments. Necessary steps should be taken by DAE, BADC and NGOs in supplying quality seed and providing technical and financial support. In the favorable production environment, poverty could be reduced through supplying improved seeds for vegetable cultivation.

Research Institutes can play a role in the development of appropriate seeds in all the environments. This would obviously help households to increase their on-farm income.

Since the road infrastructure in the flood-prone environment is extremely poor, steps should be taken to improve the physical infrastructure. The improvement in communication system would obviously enable resource-poor farmers to generate additional income.

References

BBS (Bangladesh Bureau of Statistics), 2015, Statistical Pocket Book of Bangladesh, Statistics Division, Ministry of Planning, Government of the Peoples Republic of Bangladesh.

Brahmmer, H, 1997. Agricultural Development Possibilities in Bangladesh. University Press Limited, Bangladesh.

Ellias, F., 2000. Rural Livelihoods and Diversity in Developing Countries, Oxford, UK

Hussain, K., and J.Nelson, 1999. Sustainable livelihoods and livelihood Diversification. IDS Working Paper 69.

Orr, A. W. and N. Magor, 1992. Reducing small Farmers Vulnerability in Bangladesh. Proceedings of BRRI Workshop, Joydebpur, 30-31 May, BRRI.

Reordan, T., 1997. Using Evidence of Household Income Diversification to Inform Study of Rural Non-farm Labour Market in Africa. World development, Vol.25, No.5, PP.735-747.

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Mobilizing Education for Sustainable Development Program in the Regional Centre of Expertise Greater Dhaka:

IUBAT Whole-Institution approach of Global Action Program

Muhammad Rehan Dastagir,
Department of Environmental Science
IUBAT– International University of Business Agriculture and Technology
Uttara, 1230

Mohammed Ataur Rahman,
IUBAT–
International University of Business Agriculture and Technology
Uttara, 1230

Muhammad Azizul Hoque
Bangladesh Forest Research Institute
Liaison Office,
Dhaka-1000

ABSTRACT: *This paper describes the holistic approach of an academic institution in pursuing the environmental dimension of the Sustainable Development Goals (SDGs). International University of Business Agriculture and Technology (IUBAT) is host of the Regional Centre of Expertise (RCE) Greater Dhaka. It has been taking various steps, based on the Global Actions Program (GAP), to support sustainable education. The sustainability practices include energy saving, waste water reuse, waste management, tree plantation, reduction of carbon footprint, greening the campus, etc. IUBAT, as the RCE Greater Dhaka, is a pioneer institution playing a crucial role in disseminating sustainable education to students, youth and the wider community. This requires a combined effort of the IUBAT faculty, students, administration and operations staff. The RCE Greater Dhaka has a nationwide impact because first, it is providing a model educational institution for sustainable activities in Bangladesh and second, it is training resource persons (such as students trained in sustainable knowledge) who will take a leading role in Bangladesh's future. This study discusses some positive achievements.*

KEYWORDS: *GAP-Global Action Programme, ESD-Education for Sustainable Development, Whole Institution Approach, RCE-Regional Centre of Expertise*

Introduction

Education for Sustainable Development (ESD) was a United Nations (UN) decade-long program (2005-2015). It played a crucial role in formal and non-formal education by up-scaling sustainable development around the world. Its role has been to educate students, teachers, the broader community and government about sustainability.

In 2003, the United Nations University Institute for the Advanced Study of Sustainability (UNU-IAS) launched the ESD project, with funding support from the Ministry of the Environment, Japan. The ESD project designs and implements research and development activities through two flagship initiatives: a global multi-stakeholder global network of Regional Centres of Expertise on ESD (RCEs), and a network of higher education institutions called the Promotion of Sustainability in Postgraduate Education and Research Network [Global RCE Network].

Moving forward, UNESCO has now presented the Roadmap for Implementing the Global Action Program (GAP) on ESD with five priorities: (i) advancing policy by mainstreaming ESD, (ii) transforming learning and training environments using the whole-institution approach, (iii) building capacities of educators and trainers, (iv) empowering and mobilizing youth, and (v) finally, accelerating sustainable solutions at the local level. At all levels of society, RCEs play a crucial role in implementing these goals using their local knowledge and global network [Proposal for GAP, 2014].

Any academic institution could be a front runner for sustainability. This article is a case study of the IUBAT whole institution approach of RCE Greater Dhaka in the area of biodiversity conservation, youth mobilization, and water reuse.

Mission and Vision of RCE Greater Dhaka

RCE Greater Dhaka's goal is to make individuals and communities aware of environmental facts, moral development, and practices that can be implemented by individuals, groups of friends and family and more widely.

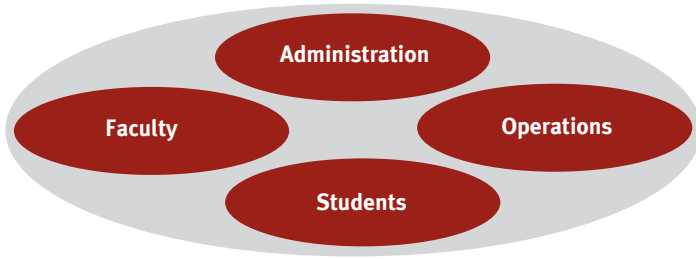
The specific objectives of the RCE are:

- To apply knowledge management science for effective management of the environment.
- To develop and integrate indigenous knowledge on environmental management and sustainability through research and consultation.
- To conduct training and workshops for executives and policy makers to develop skills in environmental management.
- To develop academic specialization on environmental studies.
- To disseminate information on environmental issues through information sharing and publication.
- To develop appropriate linkages with national, regional and international environmental organizations.
- To study ethnic and traditional wisdom and cultural practices to advance sustainability.

"Whole Institution" Approach

The IUBAT whole institution approach refers to the second priority area of the Global Action Program (GAP) in transforming learning and training environments. The university has a "green" campus with plenty of biodiversity; university programs encourage resource-saving and mobilize youth in various schools surrounding IUBAT to pursue sustainable entrepreneurship and skill development. IUBAT is green not only due to its vegetative cover but also to energy-saving activities, waste-water reuse, waste management, tree plantation, and reduction of campus carbon footprint. (See Figures 1 and 2).

Figure I: IUBAT Whole Institution Approach and its four components



I) **Faculty:** Mandatory Environmental Science education course inclusion in undergraduate level
II) **Administration:** Green campus initiative
III) **Operations:** Water reuse by greywater recycling and others
IV) **Students:** Youth Engagement in and outside campus of different institutes

Figure II: Timeline for the sustainability initiatives in the campus

Faculty for Institution: Sustainability in Course Curricula

IUBAT has approximately 8000 full time students. A sustainability course was first proposed for all students in 2013. The course curriculum and sustainability practices are intended to change student behavior. This is a pioneer ESD practice tools in Bangladesh. Every semester 500 students are trained on sustainability practices. To date we have trained 7000 students.

The Course Design

The field of sustainability aims to integrate environmental, social, and economic dimensions [Komiyama and Takeuchi, 2006]. To do so, the field draws heavily from a wide variety of foundational disciplines (e.g., geography, environmental science, ecology, economics, political science, and sociology). The field is defined more by the problems it addresses than the disciplines it employs [Clark, 2007]. While the approach to organizational design may vary, there appears to be some consensus on the core concepts that a sustainability program should address: bridging social and natural sciences [Kates and Clark 2001, Andersson et al, 2008] and understanding the interconnectedness of social, environmental, and economic systems [Tilbury, 1995].The sustainability course has been designed to create awareness among undergraduate students of local and international environmental issues and of changes in students' lifestyles to enhance sustainability.

In designing the course, we tried to achieve the following learning outcomes:

- Sustainable resource utilization

  Learning Outcome, student understanding of …:

  - Human overexploitation of the world's natural resources;
  - Limitation of natural resources on planet earth;
  - Renewable Energy Resources for future;
  - Industrialization history and global catastrophe;
  - Carbon footprint and ways to minimizing it;
- Population and human resource and its sustainable management
  - Learning Outcome, students will learn about …
  - Population growth on planet earth;
  - Hidden danger of exponential population growth;
  - Negative population growth in developed world;
  - Managing population for future economic growth;
- Climatic zones and Biodiversity

  Learning outcome, students will learn about …
  - Concepts of biodiversity and its importance;
  - Various endangered and extinct species;
  - Various climatic zones and their biodiversity in the world;
  - Conservation of biodiversity;

- Traditional wisdom

  Learning outcome, students will learn about …

  - traditional methods of sustainable adaptation practices in Bangladesh such as rainwater harvesting, pond solution for water, local varieties of agricultural crops, organic farming, tree species as wind break in natural disasters;

- Sustainability in school campus as a learning laboratory

  Learning outcome, students will learn about …

  - energy saving, waste water reuse, waste management, tree plantation, reduction of carbon footprint, greening campus;

- Soil, air and water pollution and food chain degradation and diseases

  Learning outcome, students will learn about …

  - Reasons of air, water and soil pollution;
  - Effluent Treatment Plant (ETP) for industrial wastewater management;
  - Health hazards of toxic compounds in food chains;

- Environmental Health and Safety measures for the workers

  Learning outcome, students will learn about …

  - safety in working environment and in natural disasters such as earthquakes;

- Social Equity for Sustainable Development Learning outcome:

  - a) Students will learn about avoiding gender discrimination;
  - b) They will learn about poverty reduction for sustainable development;

- Environmental Ethics

  Learning outcome, students will learn about …

  - ethical values and morals for giving priority to environmental laws over economic value nationally, globally and personally;

Through sustainability teaching we are changing attitudes towards nature and ecosystems. Students learn to optimize resource utilization in their daily lives. They learn to analyze environmental problems – including local problems. Traditional aspects of sustainability are introduced and students learn about the best indigenous solutions of local environmental problems.

Administrative effort for Green Campus

Dhaka ranks 11th among the world cities in terms of population. Due to unplanned urbanization and industrialization, its environmental condition has deteriorated severely and now Dhaka is ranked as one of the most "unlivable" cities in the world. The city lacks urban green spaces to breathe fresh air and achieve mental peace. IUBAT is situated in Uttara Model Town in the Dhaka metropolitan area. The campus was established in 2005 on open land. The university started an initiative to make the campus into the greenest in Bangladesh. It introduced indigenous and exotic species in the campus. For example, IUBAT campus has 86 tree species and a total of 777 trees, in an area of 2.6 hectares [Dastagir, 2015]. Moreover,

the campus is a laboratory for students to learn about various herbs, under-utilized crops and ornamental plants, and it has become a habitat for thousands of birds. The perennial plants include local and exotic species. They also serve as a laboratory for identification of plants for students who have very little knowledge about plants. A list of plants is given in Annexure-1. Some pictures of IUBAT Green Campus are shown below:

Figure III: Floral diversity and green space in IUBAT Green Campus

Operational or construction activity considering sustainability

In pursuit of sustainable development, the university can contribute by its operational activity. Examples at IUBAT include initiatives to reduce energy use (e.g., solar panels on laboratory buildings), to save water (e.g., grey water reuse, and to reduce automobile commuting (e.g., bus transport system). Sustainability symbols are used in the wash rooms, classrooms and corridors to remind students continuously about energy and water saving and waste management. The classrooms have large windows to maximize use of natural light. See Figure IV.

Despite Dhaka's position on a river delta, the availability of freshwater is very limited: rivers are polluted and the local groundwater level is falling. Reuse of grey water (water that has provided an initial use) could considerably decrease the pressure on fresh water sources.

Figure IV: Operational activities of the university for sustainable resource consumption

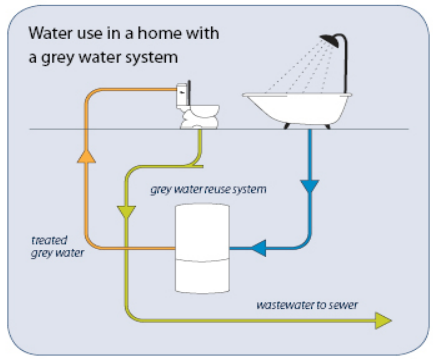
Greywater reuse

Greywater reuse includes all household wastewater from kitchen sinks, dishwashers, laundry tubs, washing machines, showers, baths and basins (shown in Figure-V). Although greywater cannot be used for cooking, bathing, brushing teeth, swimming or drinking, it reduces reliance on the mains water supply system, and allows gardens to be watered during drought periods. The treatment processes for household or building level includes:

- Biological systems, such as constructed wetlands or living wall sand bioreactors or more compact systems such as membrane bioreactors. These are variations of the activated sludge process, also used to treat sewage.
- Mechanical systems (sand filtration, lava filter systems and systems based on UV radiation)

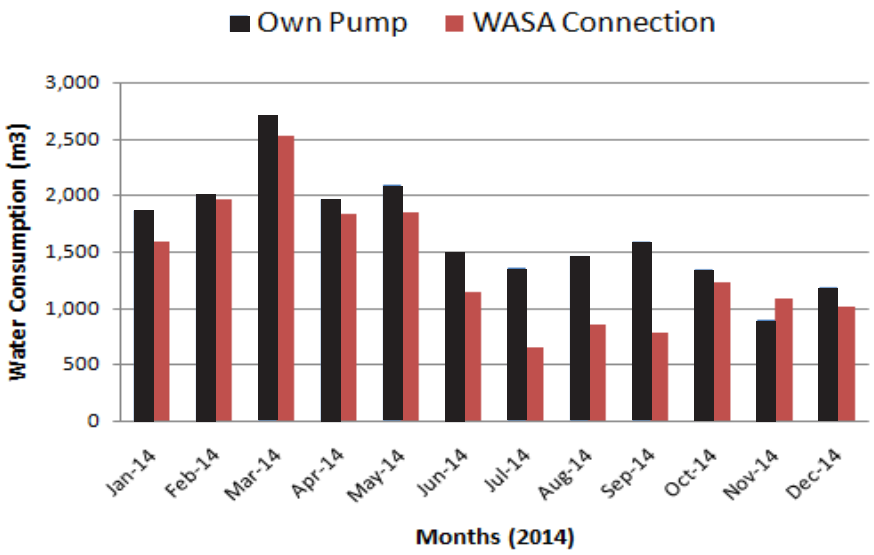
Recently, IUBAT installed greywater reuse systems for gardening purpose shown in Table I. They are estimate to save 10,500 liters of water daily. Water consumption and different purpose water usage is shown in Figure-VI and Table-I.

Figure V: A sample greywater reuse system



Source: Health Canada

Fig VI: Water consumption in IUBAT University in different months of the year



Source: Badsha, 2016

Table I: Distribution of IUBAT water usage, by different user

SL No	Name of the Consumers	Purpose	Type of water	Amount consumed (L/day)	Consumption %
1	IUBAT Community	Drinking	Filtered	4163	52.5
		Washing	Supply Water	15725	
		Flushing	Supply Water	28675	
2	Lemon Lime	Kitchen	Supply Water	2775	4
		Drinking	Filtered	925	
3	Panoramic Cafeteria	Kitchen	Supply Water	3700	5.5
		Drinking	Filtered	1388	
4	University Laboratory	Washing	Supply Water	1850	2
5	Gardening	Watering	Supply Water	10638	11.5
6	Car Washing	Washing	Supply Water	8325	9
7	Floor Cleaners	Washing	Supply Water	2313	2.5
8	Civil Construction	Construction	Supply Water	12025	13
Source: Badsha, 2016			**Total =**	**92,500**	**100**

A real scale plant for using grey water for gardening is saving money and contributing to sustainability by reducing fresh water use [Badsha, 2016].

University transport

The university has a fleet of 30 buses with service to all corners of Dhaka metropolitan city. As a result, there are fewer cars parked at the campus. The bus service reduces traffic jams on the adjacent road, reduces carbon emission and the hazard of injury due to vehicle accidents.

Figure VII: Bus service in an organization reduces the use of cars, and hereby lowers the carbon footprint of the city.

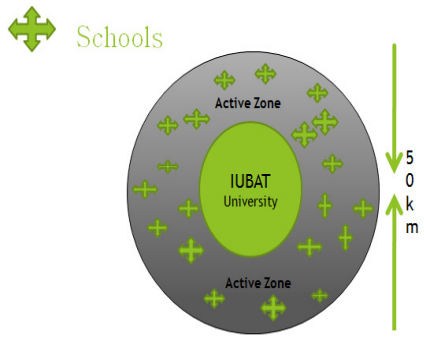
Students: Youth Engagement

In the 8th Global RCE Meeting in Philippines in 2015, RCE Greater Dhaka led the Youth Session [8th AP-RCE Meeting, 2015]. It was agreed that students undertake community or social work as part of their environmental sustainability coursework. This improves students' capacity to work on critical environmental issue, learn in detail about sustainability and finally ensures an empathetic outlook on their surrounding community. This was put into practice in 2015 and 2016 in IUBAT. The projects include IUBAT students teaching a sustainable development education class in a school or college in the surrounding community. In the demonstration class, students explain the importance of tree plantation, biodiversity conservation, energy saving and other topics. Students made banners and placards that animated their class lectures; some students used quizzes and organized a prize-giving ceremony in their volunteer class. This kind of activity made students aware of local issues and provided them with the satisfaction of having done something for the society voluntarily. RCE Greater Dhaka basically trained up the immediate resource persons of these graduate students. Students have done some excellent work for the environment and the overall outcome of the projects are shown in Table II.

Active zone of Awareness

IUBAT is the central hub of an "active zone of awareness" comprising primary and secondary schools, and colleges within 50 km (See Figure- VIII). The goal of the youth engagement program is to educate the students of all schools and colleges on ESD practices. Organizing an annual youth conference in the RCE Greater Dhaka is one of the responsibilities of the program [Dastagir, 2016].

Fig VIII: School campaign of RCE Youths for environmental awareness



Based on practical projects, constant feedback, and links to the community, students are learning sustainable entrepreneurship skills. Each youth individual entrepreneur becomes a future leader in every relevant environmental sector. The potential for sustainable development this century is immense. The main focus should therefore be on youth development. Moreover, engagement of youth does not mean only academic study; it also means the development of interpersonal skills, the urge to bring about changes in themselves.

Table II: Youth Campaign in Schools and Colleges (Total Students number/ semester: 150)				
Summary of Activities in year 2015, 2016				
Sl no	**School campaign**	**Location**	**Campaign theme**	**Online resources**
1	Khandoker Rojob Ali Bidda Niketon	Tongi, Gazipur	Water Saving	facebook.com/iubatyf
2	Kaichabari Primary School	Savar, Gazipur	Recycling product	facebook.com/ groups/IubatEnv
3	Abdur Rahman High School	Tongi, Gazipur	Health Hygiene	youtube.com/ watch?v=88ucHc__lkI
4	Dhaka Brilliant School	Uttara, Dhaka	Slum Health	youtube.com/ watch?v=nPlzTuWNueA
5	Golden Life Ideal School	Gazipur	Anti-smoking	greenearth.tk/work.html
6	Mazida high school	Tongi, Gazipur	Road safety	
7	Barakau Govt Primary school	Gazipur	Earthquake preparedness	
8	The Amirat School and College	Uttara 10, Dhaka	Tree Plantation	
9	Turag model school	Turag, Dhaka	Tree Plantation	
10	Talents High School and College	Azampur, Uttara, Dhaka	Biodiversity saving World Env Day 2016	facebook.com/iubatyf/
11	Brac School	Mirpur-2, Dhaka	Biodiversity saving World Env Day 2016	facebook.com/ groups/IubatEnv/
12	Western Laboratory School	Uttara Sector 10, Dhaka	Biodiversity saving World Env Day 2016	youtube.com/ watch?v=88ucHc__lkI
13	Paradise School and College	Uttara Sector 10, Dhaka	Biodiversity saving World Env Day 2016	youtube.com/ watch?v=nPlzTuWNueA
14	Dhaka Paramount School and College	Uttara, Dhaka	Biodiversity saving World Env Day 2016	greenearth.tk/work.html
15	Brac Kishori Club	Dhaka	Biodiversity saving World Env Day 2016	
16	Mevis Int. School and Institute	9, Uttara, Dhaka	Biodiversity saving World Env Day 2016	
17	Dhour Govt. Primary School	Turag, Dhaka	Biodiversity saving World Env Day 2016	
18	Dr. Muhammad Shahidullah Model High School	Dhaka	Biodiversity saving World Env Day 2016	

Table II: Cont.				
19	Blooming Flower International School and College	Uttara Dhaka	Biodiversity saving World Env Day 2016	facebook.com/iubatyf/
20	Grace International School	Uttara Sector 11, Dhaka	Biodiversity saving World Env Day 2016	facebook.com/groups/IubatEnv/
21	Uttara Ideal High School	Ranavola, Turag, Dhaka	Biodiversity saving World Env Day 2016	youtube.com/watch?v=88ucHc__lkI
22	Parashmoni Laboratory School	Uttara Sector 10, Dhaka	Biodiversity saving World Env Day 2016	youtube.com/watch?v=nPlzTuWNueA
23	Stamford College	Uttara, Dhaka	Biodiversity saving World Env Day 2016	youtube.com/watch?v=nPlzTuWNueA

Challenges and Future Direction of ESD program

Enormous challenges exist in the ESD program of RCE Greater Dhaka. The regional centre would like an integrated effort among IUBAT faculty, administration, engineering and student body on behalf of sustainable development. The biggest limitation for a non-government institution in a developing country is lack of resources. For five of the last six years, IUBAT received the United Nations University global RCE centre best sustainability practice award. However, IUBAT needs financial support from home and abroad for its sustainable development program. Another challenge is realizing effective coordination among faculty members, students, administration and engineering department. Knowledge gaps exist and not all within IUBAT are equally informed about the potential for sustainable development. Greater awareness has to be developed.

In summary, the future direction of this regional centre requires the following:

- Extending and strengthening partnership with UNESCO
- Expand ESD from IUBAT University to other universities, and then school and colleges
- Create green campuses in other educational institutions as at IUBAT
- Develop an ESD textbook with appropriate pedagogy and local context
- Involve rural communities through the Knowledge Based Area Development (KBAD) program of IUBAT for financial assistance to marginalized people across the country

Conclusion

RCE Greater Dhaka is trying to scale up ESD in a holistic way. This requires integrating activities among different components of the university – among faculty, students, administration and operation on behalf of sustainable development. There are enormous challenges

in this process but many obstacles have been overcome. Sustainable Development education by developing appropriate course curricula is the biggest achievement so far: 7000 students have been trained on sustainable development education. Youth are being activated through school-based project work; awareness campaigns have been undertaken in 50 schools. The IUBAT campus is noticeable in Dhaka city for its greenery and floral diversity. We now consider environmental impacts for all construction projects on the campus and integrate sustainability in engineering processes. A sustainability culture is gradually developing in the university. This is very optimistic indeed.

Acknowledgement

RCE Greater Dhaka is deeply acknowledging its founder Chairman and late Vice-Chancellor Professor Dr. M Alimullah Miyan for his active support of sustainable development education in IUBAT.

Reference

Andersson, K., Burns, M., Bursztyn, M., Douglas, A.H., Laudati, A., Matus, K., McNie, E., (2008). *The Ruffolo curriculum on sustainability science*: 2008 Edition. Center for International Development at Harvard University, December 2008.

Badsha, A. H., "Daily Water Consumption at IUBAT University and How to Reduce the Fresh Water Demand"|, conference paper in the *Seminar on Industrial Wastewater Treatment System in the Context of Bangladesh*, 20th March, 2016, IUBAT University, Bangladesh.

Clark, W. C. (2007). Sustainability science: a room of its own. *Proc Natl Acad Sci* 104:1737–1738.

Clark, W.C., Dickson, N.M. (2003). Sustainability science: the emerging research program. *Proc Natl Acad Sci* USA 100(14):8059–8061.

Dastagir, M. R., "Education for Sustainable Development in IUBAT, Bangladesh", conference paper in *Environmental Policies and Acts Implementation Problems* of BAPA-BEN Conference, 10th January, 2015. Dhaka.

Global RCE Network, Education for Sustainable Development, Retrieved on 30/06/2016, http://www.rce-network.org/portal

International University of Business agriculture and Technology (IUBAT), Retrieved on 30/06/2016. http://iubat.edu

8th Asia-Pacific RCE Meeting 2015, Cebu, Philippines, Youth Session.

Komiyama, H., Takeuchi, K. (2006). Sustainability science: building a new discipline. *Sustain Sci* 1:1–6.

Kates, R., Clark, W. (2001). Sustainability science. *Science* 292(5517):641–642.

Proposal for a Global Action Programme (GAP) on Education for Sustainable Development as Follow-Up to the United Nations Decade of Education for Sustainable Development (DESD) after 2014. Source: 36 C/Resolution 16, 190 EX/Decision 9 and 192 EX/Decision 6. General Conference, Paris, 37th Session 2013.

RCE Greater Dhaka, Bangladesh, Retrieved on 30/06/2016 http://www.rcegreaterdhaka.org

Tilbury, D., (1995). Environmental education for sustainability: defining the new focus of environmental education in the 1990s. *Environ Educ Res* 1(2):195–212

Annexure – I

Floral Biodiversity in IUBAT University campus

SL	Common Name	Scientific Name	Family	Number
1	Krishnachura	*Delonix regia*	Fabaceae	131
2	Mahogany	*Swietenia macrophyllus*	Meliaceae	85
3	Alamanda	*Allamanda cathartica*	Apocynaceae	35
4	Thuja	*Platycladus orientalis*	Cupressaceae	30
5	Banana	*Musa acumita*	Musaceae	25
6	Mango	*Mangifera indica*	Anacardiaceae	23
7	Jackfruit	*Artocarpus heterophyllus*	Moraceae	20
8	Chip Bash(Bamboo)	*Bambusa sp.*	Poaceae	20
9	Palmyra palm	*Borassus flabellifer*	Arecaceae	18
10	Guava	*Psidium guajava*	Myrtaceae	13
11	Baganbilas	*Bougainvillea spectabilis*	Nyctaginaceae	10
12	Ixora/Rangon	*Ixora coccinea*	Rubiaceae	10
13	Ivory Cane Palm	*Pinanga coronata*	Aracaceae	10
14	Basil/Tulsi	*Ocimum tenuiflorum*	Lamiaceae	10
15	Mast Tree/Debdaru	*Polyalthia longifolia*	Annonaceae	8
16	Gmelina/Gamar	*Gmelina arbroea*	Lamiaceae	8
17	Plum/Boroi	*Ziziphus mauritiana*	Rhamnaceae	8
18	Lemon/Lebu	*Citrus limon*	Rutaceae	8
19	Bokul	*Mimosops elengi*	Sapotaceae	7
20	Arjun	*Terminalia arjuna*	Combretaceae	6
21	Rain tree	*Albizia saman*	Fabaceae	5
22	Fig/Bot	*Ficus carica*	Moraceae	5
23	Neem	*Azadirachta indica*	Meliaceae	5
24	Blackberry/Kalojam	*Syzgium cumini*	*Myrtaceae*	5
25	Cinamon/Daruchini	*Cinnamomum verum*	Lauraceae	5
26	Kadam	*Neolamarckia cadamba*	Rubiaceae	5
27	Madhobilota	*Hiptage benghalensis*	Malpighiaceae	5
28	Oil palm	*Elaeis guineensis*	Arecaeae	4
29	Shishu	*Dalbergia sissoo*	Fabaceae	4

SL	Common Name	*Scientific Name*	Family	Number
30	Papaya	*Carica papaya*	Caricaceae	4
31	Coconut	*Cocos Nucifere*	Arecaceae	4
32	Togor	*Tabernaemontana divaricata*	Apocynaceae	4
33	Kathgolap	*Plumeria alba*	Apocynaceae	4
34	Rajkoroi	*Albizia richardiana*	Fabaceae	3
35	Cycas	*Cycas pectinatus*	Cycadaceae	3
36	Jarul	*Lagerstroemia speciosa*	Lythraceae	3
37	Kopper's tree	*Peltophorum pterocarpum*	Fabaceae	3
38	Ataphol	*Annona cherimola*	Annonaceae	3
39	Bay leaf/Tejpata	*Cinamomum tamala*	Lauraceae	3
40	Ebony/Bilati gaab	*Diospyros blancoi*	Ebenaceae	3
41	Olive/Jalpai	*Elaeocarpus floribundus*	Elacocarpaceae	3
42	Kamini	*Murraya paniculata*	Rutaceae	3
43	Sunalu	*Cassia fistula*	Fabaceae	2
44	Pomegranate/Dalim	*Punica granatum*	Lythraceae	2
45	Areca nut/Supari	*Areca catechu*	Arecaeae	2
46	Starfruit/Kamranga	*Averrhoa carambola*	Oxalidaceae	2
47	Amloki	*Emblica officinalis*	Phyllanthaceae	2
48	Litchi	*Litchi chinensis*	Sapindaceae	2
49	Hog plum/Amra	*Spondias dulcis*	Anacardiaceae	2
50	Date/Khejur	*Phoenix dactylifera*	Arecaceae	2
51	Clove/Lobongo	*Syzygium aromaticum*	Myrtacaea	2
52	Wax apple/Jamrul	*Syzygium samarangense*	Myrtaceae	2
53	Monkey jack/Deowa	*Artocarpus lacucha*	Moraceae	2
54	Cardamom/Elach	*Elettaria cardamomum*	Zingiberaceae	2
55	Henna/Mehedi	*Lawsonia innermis*	Lythraceae	2
56	Garcinia/Kao	*Garcinia cowa*	Clusiaceae	3
57	Tamarind/Tetul	*Tamarindus indica*	Fabaceae	1
58	Drumstick/Sajna	*Moringa oleifera*	Moringaceae	1

SL	Common Name	Scientific Name	Family	Number
59	Sapodita/Sofeda	*Achras sapota*	sapotaceae	3
60	Castor/Veranda	*Ricinus communis*	Euphorbiaceae	1
61	Dragon fruit	*Hylocereous undatus*	Cactaceae	1
62	Pomelo/Jambura	*Citrus maxima*	Rutaceae	1
63	Wood apple/Bel	*Aegle marmelos*	Rutaceae	1
64	Avocado	*Persea americana*	Lauraceae	1
65	Lotkon	*Baccaurea sapida*	Phyllanthaceae	1
66	Fig/Dumur	*Ficus carica*	Moraceae	1
67	Agar tree	*Aquilaria malaccenaia*	Thymelaeaceae	1
68	Elephant apple/Chalta	*Dillenia indica*	Dilleniceae	1
69	Wax apple/Golap jam	*Syzygium jambos*	Mytaceae	1
70	Orboroi	*Phyllanthus acidus*	Phyllanthaceae	2
71	Malotilata	*Combretum indicum*	Combretaceae	10
72	Myrobalan/Haritaki	Terminalia chebula	*Combretaceae*	1
73	Grape/Angur	*Vitis vinifera*	Vitaceae	6
74	Rambutam	*Nephelium lappaceum*	Sapindaceae	1
75	Sonalu	*Cassia fistula*	Fabaceae	1
76	Marula Tree	*Scelerocarya birrea*	Anacardiaceae	6
77	Musanda	*Mussaenda erythrophylla*	Rubiaceae	3
78	Shehora	*Streblus asper*	Moraceae	5
78	Acai palm	*Euterpe oleracea*	Arecaceae	1
79	Custard apple/Sharifa	*Annona squamosa*	Annonnaceae	3
80	Basil/Babui Tulsi	*Ocimum basilicum*	Lamiaceae	10
81	Pitali	*Trewia nudiflora*	Euphorbiaceae	17
82	Peacock/Radhachura	*Caesalpinia pulcherrima*	Fabaceae	5
83	Arjuna/Arjun	*Terminalia arjuna*	Combretaceae	2
84	Jiga/Jeol Bhadi	*Lannea coromandelica*	Anacadiaceae	5
85	Karinda/ Karamcha	*Carissa carandas*	Apocynaceae	1
86	Kanchon	*Phanera variegata*	Fabaceae	1
Total Number of Plant				**777**

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Md. Monirul Islam and Rifat Sumona Mollik. 2017. "Arsenic risk analysis of Bangladesh using geographical information system." *IUBAT Review* 1 (2): 65-68. iubat.edu/journal

Arsenic risk analysis of Bangladesh using geographical information system

Md. Monirul Islam
IUBAT–International University of Business Agriculture and Technology
Uttara, 1230

Rifat Sumona Mollik
Dhaka University of Engineering and Technology, Gazipur
IUBAT–International University of Business Agriculture and Technology
Uttara, 1230

Introduction

Arsenic contamination of ground water is a widely prevalent phenomenon in Bangladesh. It is a form of groundwater pollution due to naturally occurring high concentrations of arsenic in deeper levels of groundwater. Arsenic contamination of groundwater in Bangladesh was discovered by the School of Environmental Studies (SOES) in 1992 (Dhar et al., 1997). The natural contamination of tube wells has led to widespread human exposure to arsenic through drinking water (Dhar et al., 1997). Since consumption of cereals and vegetables is a significant route of human exposure to arsenic, use of groundwater for irrigation of crops raises the question of arsenic uptake in food. The impact of arsenic-contaminated irrigation on rice is especially important as rice is the major staple food, and it may be grown in soil where irrigation has introduced arsenic from groundwater. Arsenic contamination in irrigation would be a toxic to rice leading to reduced yields (Paul, B.K. et. al. 2000). Shallow aquifers (20–70 m) generally have the highest levels of arsenic. The present study dealt with the map of irrigation land coverage, population, arsenic contamination of ground water and then converted the map into the Geographical Information System (GIS) data and maps, and then utilized the arsenic effect on irrigated land coverage and arsenic impact on population. Six categories of arsenic contamination maps were used to assess the levels of arsenic in different areas of Bangladesh. A risk map for administrative districts of Bangladesh was developed using both irrigation and population maps, interacting with groundwater arsenic concentration map (developed by Jakaria 2000).

Methodology

Data Preparation and Analysis

An arsenic contamination map was prepared on the basis of arsenic contamination levels. Six categories of arsenic contamination were defined: 1. uncontaminated (0 – 10 ppm), 2. low contamination (10 – 50 ppm), 3. contaminated (50 – 150 ppm), 4. highly contaminated (150 – 500ppm), 5. severely contaminated (500 – 1000 ppm), 6. extremely contaminated (1000 – 2000ppm). We obtained population and irrigation categorized maps, developed by the Bangladesh Bureau of Static and Bangladesh Agriculture Department. We superimposed these maps onto the base groundwater contamination map and converted them in to GIS data. The Population map employs five categories: 1. population density <500 persons/km^2, 2. 501 - 1000 persons/km^2, 3. 1001 – 1500 persons/km^2, 4. 1501 – 2000 person/km^2, 5. >2000 persons/km^2. The irrigation map employs four categories defined in terms of extent of area irrigated: 1. <25%, 2. 25 – 50%, 3. 50 – 75%, 4. 75 – 100%.

Hazard maps

We developed a model that required two hazard maps, using the interaction of arsenic groundwater contamination categories with first population density and second irrigation extent. The schematic concept of the model is shown in Figure 1. Islam and Sado (2000 and 2002) developed the concept of a ranking matrix defined by multiplication to determine a flood hazard and flood risk map. In this study, their concept of a ranking matrix was used to develop the two hazard maps and the final risk map. To generate the two hazard maps, we superimposed the district-based map categorizing arsenic concentration in groundwater (6 categories) on respectively the district-based map showing population concentration (5 categories) and the map showing irrigation extent (4 categories). This exercise generated 30 hazard ranks in the former and 24 in the latter map. Finally, the hazard ranks were aggregated into three categories: arsenic-population matrix aggregated ranks – low (1 – 6), medium (8 – 15), high (16 – 24); arsenic-irrigation – low (1 – 9), medium (10 – 18), high (20 – 30) shown in Table 1.

Table 1 Categories of hazard rank using ranking matrix

Population Category \ Arsenic Contamination Category	1	2	3	4	5	6
1	1	2	3	4	5	6
2	2	4	6	8	10	12
3	3	6	9	12	15	18
4	4	8	12	16	20	24
5	5	10	15	20	25	30

a) Categories of arsenic-population hazard map

Irrigation Category \ Arsenic Contamination Category	1	2	3	4	5	6
1	1	2	3	4	5	6
2	2	4	6	8	10	12
3	3	6	9	12	15	18
4	4	8	12	16	20	24

b) Categories of arsenic-irrigation hazard map

Risk analysis

High level of arsenic in water for drinking or cooking or in irrigated fields may lead to serious health problems, such as melanosis, leuko-melanosis, hyperkeratosis, black foot disease, hepatomegaly, neuropathy and cancer (Khan and Ahamed, 1997). In this study, the arsenic vulnerability data were prepared in the form of GIS data using the arsenic vulnerability map which was developed by Jakaria (2000) on the basis of the presence of arsenic in soil and water, and arsenic patients. Jakaria's map used three categories:

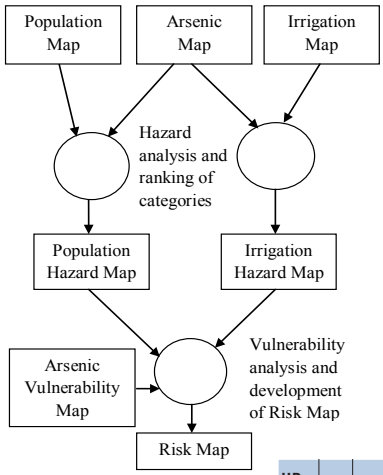
1. arsenic found with high arsenic levels in soil and ground water and in patients' blood,
2. arsenic found in soil and groundwater and
3. arsenic not detected.

In order to quantify the arsenic risk, the two hazard maps were set against vulnerability data (from Jakaria's map) by using Eq. 1 and developed two risk maps for arsenic-population effect and arsenic-irrigation effect.

Risk = vulnerability x hazard (1)

These two maps were categorized into three categories 1, 2 and 3 by using the score of the risk. Finally, a risk map was developed by considering the interactive effect of two risk maps using the ranking matrix of two-dimensional multiplication modes (shown in Fig. 1) with six risk ranks; 1, 2, 3, 4, 6 and 9 drawn from the 3 x 3 ranking matrix for the administrative districts of Bangladesh. The final result is shown in Figure 2.

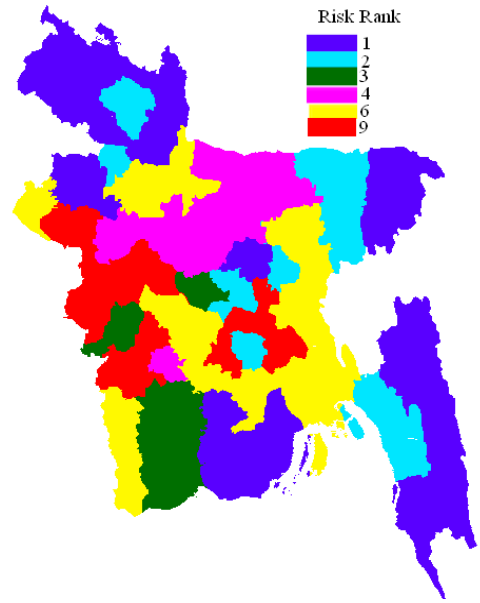
Figure 1: Flowchart of the model and ranking matrix



HR	1	2	3
1	1	2	3
2	2	4	6
3	3	6	9

Ranking Matrix

Figure 2: Arsenic contamination risk map for administrative district



Conclusions

Arsenic risk assessment was performed using arsenic contamination levels against both population density and irrigation density, defined for the administrative districts of Bangladesh. This risk map may help the responsible authorities to better comprehend the arsenic effect on the country's population and food. The general public may become more aware of the risk of arsenic in different districts of the country.

References

Dhar, R.K., Biswas, B.K., Samanta, G., Mandal, B.K., Chakraborti, D., Roy, S., Zafar, A., Islam, A., Ara, G., Kabir, S., Khan, A.W., Ahmed, S.A., Hadi, S.A., 1997. Groundwater arsenic calamity in Bangladesh. Current Science 73, 48e59.

Paul, B.K.; De Sujata, D.; De, S., 2000. Arsenic poisoning in Bangladesh—a geogra-phical analysis. Journal of the American Water Research Association 36, 799–809.

Jakaria, M., 2000. The use of alternative safe water options to mitigate the arsenic problem in Bangladesh: a community perspective. M.Sc. Thesis. Department of Geography, University of Cambridge, UK.

Islam, M. M, and Sado, K., 2000. Development of flood hazard maps of Bangladesh using NOAA-AVHRR images with GIS, Hydrol. Sci. J., 45(3), 337-355

Islam, M. M, and Sado, K. Development priority map for flood counter measure by remote sensing data with geographical information system, Journal of Hydrological Engineering, Vol. 7. No. 5, Sept. 1, 2002. ASCE, 346-355.

Khan, A.W., Ahmad, S.K.A., 1997. Arsenic in Drinking Water: HealthEffects and Management. A Training Manual Department of Occupa-tional and Public Health, National Institute of Preventive and SocialMedicine (NIPSOM), Dhaka.

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Techniques of Rapid Prototyping and Comparision with Computer Numerically Controlled Machining

Arijit Sen

Department of Mechanical Engineering
IUBAT—International University of
Business Agriculture and Technology
Uttara, 1230

ABSTRACT: *Rapid prototyping is a developing technology in product design and manufacturing. This paper describes the various techniques of rapid prototyping and compares the cost and surface quality of prototypes produced in fused deposition modelling and 3D printing with that of CNC (Computer Numerically Controlled) machining. It was found that the fused deposition modelling method produces the prototype with the best surface quality and CNC machines produce the prototype at least cost.*

KEYWORDS: *Fused deposition modelling, Rapid prototyping, 3D printing.*

Introduction

Rapid prototyping is an expanding field in the design and manufacturing industry. Prototyping is the task between the design and manufacturing phase of a product. It ensures the designers that the product is going to conform to the design specification and also reveals the hidden defects, if any exists that cannot be detected either by design drawing or by 3D CAD model. The traditional way of making a prototype is material removal from a block, either by using hand tools or with the help of machine tools. To build prototypes with these processes takes much time; however, with the development of CNC machining the time required has been reduced to some extent. A new technique of making prototype, 'Rapid Prototyping' (RP), has developed since the 1980s. Rapid Prototyping is "a generic term for a number of technologies that enable components to be made without the need for conventional tooling in the first instance or indeed without the need to engage the services of skilled model-makers" (Upcraft and Fletcher, 2003). The input of a rapid prototyping process is a 3D CAD model, which can be visualised only, and the output, which is the physical replica of that 3D CAD model. Rapid prototyping will eventually move into the heart of the manufacturing process and end use parts will be made by these techniques (Dickens, 2001). The growing popularity of this process can be found by looking at the increasing market volume of rapid prototyping machines, from US$1.5 billion in 2011 to US$4.2 billion in 2015 (Muller and Karevska, 2016).

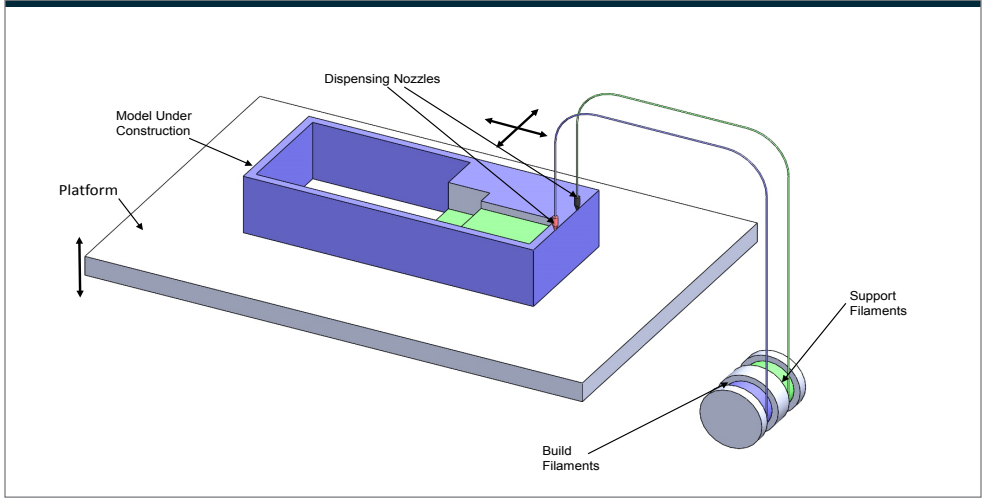
Different Techniques of Rapid Prototyping

The conventional prototyping process is subtractive: it removes material from a block. In contrast, rapid prototyping is an additive process: it builds the model by adding successive layers. In order to form such a model, 3D CAD models are sliced into layers using software in the prototyping machine. Accumulation of those layers results into the desired prototype. There are different techniques of rapid prototyping, such as a) fused deposition modelling, b) stereo lithography, c) selective laser sintering, d) ballistic particle manufacturing, e) 3D printing, f) laminated object manufacturing, and g) film transfer imaging technology. In addition, a combination of additive and subtractive processes for making more accurate prototypes, called hybrid prototypes, is also available.

Fused Deposition Modelling

Figure 2.1 shows a schematic view of the fused deposition modelling process. it includes a head that can move in X and Y directions simultaneously, and a table which can move in Z direction. The head deposits molten material on a board, which is placed upon the table, to create a layer. After completing one layer the table goes slightly down and the next layer is built upon the previous layer in the same way. This process continues until the full model is produced. To build an overhanging portion of a part it needs a support which is built in the same way as the model, using a different material.

Figure 2.1: Schematic view of fused deposition modelling.

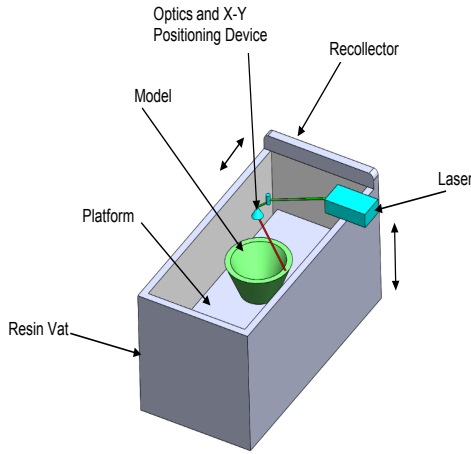


The model and the support are made simultaneously, and after finishing the model construction, the support is removed. Two heads work together – one is used for building the actual model and another for building the support, if required. The material used for making the model is generally thermoplastic or wax; the support material is generally weaker than the model material, and can be broken or easily dissolved. A honey-comb profile is used for making the support, to reduce the consumption of material and hence lower the cost.

Stereo Lithography

In this process, the layers of the model are built by curing resin, generally using an ultraviolet laser beam. A laser head can move in X and Y directions freely, and a table can move in Z direction. The table is located inside the container of resin. Figure 2.2 shows a schematic illustration of this method in which the table is kept initially in a position such that a very thin layer of resin exists on the table.

Figure 2.2: Schematic view of stereo lithography modelling.



This layer is then cured by laser beam to generate the first layer of the model. The table is then slightly lowered and the next layer is built. By continuing this process many times, the final model is obtained. Afterwards, the model is treated in an ultraviolet oven. The overhanging portion needs support, which is removed later. The materials used are a mixture of acrylic monomers, oligomers (polymer intermediates) and a photo initiator in this process (Kalpakjian and Schmid, 2006). In this process, the uncured resin can be reused.

Selective Laser Sintering

Selective laser sintering also uses a laser beam but instead of using resin to form the prototype, it uses a powder material. As with other methods, a laser head can move freely in the XY plane and a table can move vertically as shown in figure 2.3.

The materials used for this process are powder forms of polymers such as ABS, PVC, nylon, polyester, polystyrene and epoxy, wax, metal and ceramic – with an appropriate binder (Kalpakjian and Schmid, 2006). The unused powder can be used again.

Ballistic Particle Manufacturing

Ballistic particle manufacturing uses an ink jet head able to move along three axes. This ink jet head ejects small droplets of material on a surface to build the layers of a model. A piezoelectric pump is used to eject droplets. Materials used to support the overhanging portions of the prototype are plastic, ceramic, metal and wax (Kalpakjian and Schmid, 2006).

Three-Dimentional Printing

The 3D printing process uses powder and glue to build the model. It uses the principle of the ink jet printer. However, the printer head sprays glue instead of ink.

Figure 2.3: Schematic view of selective laser sintering

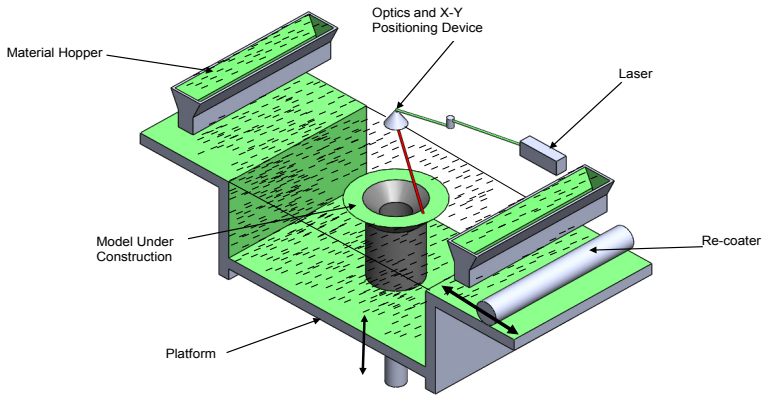


Figure 2.5: Schematic view of three-dimensional printing

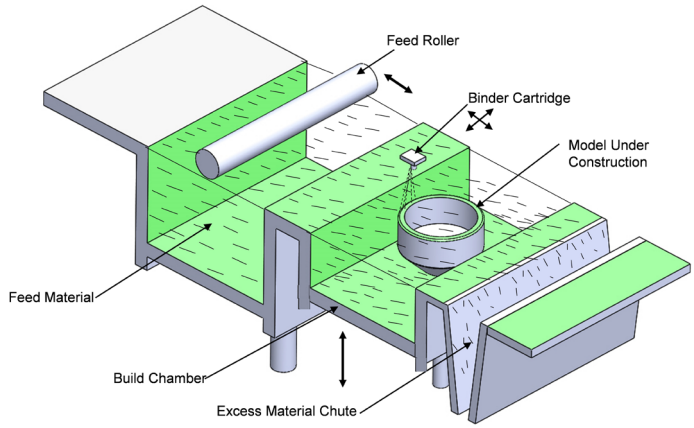
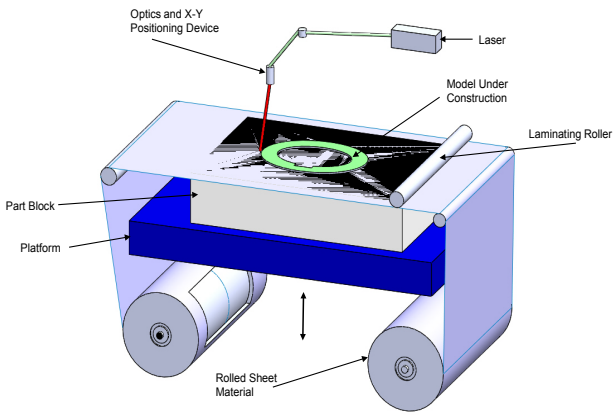


Figure 2.5 is a schematic view of the 3D printing process. There are two containers – the feed material chamber remains full of powder; the build chamber is empty at the beginning. Both have a moving base, which can travel in the Z direction, whereas the printer head can move in X and Y directions, like an ink jet printer. At the beginning of the process the empty container's base is at the top of that container. A feed roller is used to spread a thin layer of powder over that base. The printer head then sprays glue on the powder according to the cross-sectional profile of the model to build the first layer. Once a layer is made, the base of the build chamber is lowered and the base of the feed material chamber is raised slightly. The whole process is repeated to produce the full prototype model. Like the selective laser sintering method, this method doesn't need any extra support for the overhanging portion of parts because powder serves this purpose. Moreover, excess powder can be used again.

Laminated Object Manufacturing

In this process, the object is made of layers of papers or plastic sheet containing adhesive. The layers are added together by applying heat, as shown in figure 2.6. The excess portion of the sheet that does not form the cross-sectional layer of the model is burnt out by a laser. The sheet material is fed by two rollers one at each end of the table on which the forming of layers takes place. Heat is applied to add a layer. Once a layer is formed, the table is lowered slightly and more sheet material is fed to produce the next layer. This process continues until the whole model is developed. The laser head is able to move in XY planes freely.

Figure 2.6: Schematic view of laminated object manufacturing method



Film Transfer Imaging Technology

Film Transfer Imaging (FTI) technology is the most recent development in the field of rapid prototyping. It has the advantages of increased speed, higher quality, and efficiency. In this method, a layer is constructed by curing resin with an ultraviolet flash of the cross-sectional image. A build pad is used; it is lowered to a table containing a thin layer of resin. The resin is cured by the ultraviolet photoflash of the cross sectional image of the prototype. This process continues until the whole model is built. (Vflash Brochure, 2008)

Case Study

Rapid prototyping was used in a bicycle tyre manufacturing company in Calgary where the tyre company needed to produce a master pattern for a casting mould. Traditionally, the tyre manufacturing company made the rough pattern by a machining process and then finished it by hand. The process was lengthy, taking 6 to 8 weeks to produce a set of moulds due to the complex shape of the tyre tread (Yan and Gu,1996). It was suggested that, by using Solider 4600 of Cubital America Inc., a 15-inch thick master pattern consisting of 254 layers, having 150 µm layer thicknesses, could be made within 8 hours. Solider 4600 is a system that uses light-curable acrylate photopolymer and a photo-masking technique to produce patterns. To build a new air-breathing planner array fuel cell, a process called MEM was used, which took about 12-36 hours. After switching to rapid prototyping, it took roughly one hour to finish the task, much faster than even CNC machines, which took two hours (Chen et al., 2008). Rapid prototyping significantly reduces design to production lead time and material wastage in manufacturing high performance sportswear (Chowdhury et al., 2012). In assembly operation, the use of Rapid prototyped models develop better understanding of assembly sequence, assembly time and resource required than 3D digital model (Ahmad et al., 2015).

Experiment

The author conducted an experiment to make prototypes using rapid prototype technologies and a CNC machine. The goal was to compare the surface quality, cost of production, and time required to produce model using both technologies.

The techniques for rapid prototyping are fused deposition modelling and three-dimensional printing. A computer mouse was chosen as a prototype for the experiment. The mouse was designed using the CAD software SolidWorks. The material used for fused deposition modelling was plastic, for 3D printing starch powder, and for CNC machine wood. Dimension SST1200 was used for the fused deposition modelling technique. Zcorp 310 was used for 3D printing technique. The CNC machining technique used Denford router 2600.

Comparison

Table 1 compares the three methods of producing the model in terms of material requirements, time required. Figure 3 shows visually the surface finishing of all the models lined up. The evaluation of surface quality by visual and touch inspection is shown in Table 1. The Dimension SST1200 machine used 100 cc material including the support and the total cost of material is £25.00, whereas the Zcorp 310 machine used 46 cc material, which cost £5.98 and super glue cost £3.00 resulting in a total cost of £8.98. The CNC machine used 100 cc material and cost only £1.00.

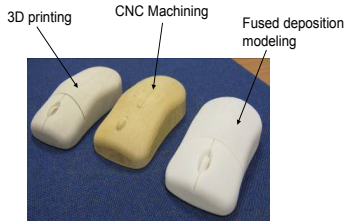
The total time taken for fused deposition modelling was 9 hours 20 minutes of which 4 hours to remove the support. 3D Printing required 1 hour 20 minutes to make the model and an additional half an hour to glue it. CNC machining was the cheapest and quickest process in this case. From visual and touch inspection of the surface quality, it produced a poorer quality surface than the other two techniques. For a large model this roughness of surface may be neglected; however, for small scale and precise models this roughness can change the shape of the object.

The model produced in fused deposition modelling technique had the best surface finishing and was strong enough to be used in a real system to some extent; however its cost and manufacturing time were the highest among the three options. Therefore, a trade-

Table 1: Comparison of cost, time required, material required and surface quality

Process	Total Cost (£)	Time Required (hour)	Material Required (CC)	Surface Quality
Fused deposition modeling (Dimension SST1200)	25	9.33	100	Smooth
3D Printing (ZCorp 310)	8.98	1.83	46	Average
CNC Machining	1	0.5	100	Rough

Figure 3: The finished models made by above mentioned processes.



off between cost and quality arises. For large models, as surface finishing is a minor concern, CNC machining is appropriate because it is cheaper and less time consuming while, for small and precise models with intricate shapes, fused deposition modelling is the best option because for small scale models surface quality is more important than cost.

Conclusion

Rapid prototyping is a powerful tool for making prototypes; it can sometimes also be used for mass production. The different types of rapid prototyping techniques discussed in this paper need to be developed further in terms of producing high quality, low cost product at a faster production rate. From this study, it can be concluded that the CNC machining is the cheapest and quickest process to produce prototype; however, the surface quality is far better in rapid prototyping.

References

Ahmad, A., Darmoul, S., Ameen, W., Abidi, M. H. and Al-Ahmari, A. M. (2015) "*Rapid Prototyping for Assembly Training and Validation*", *IFAC-Papers On Line*. Elsevier Ltd., Volume 48, Issue 3, Pages 412– 417. doi: 10.1016/j.ifacol.2015.06.116.

Chen, C. Y., et al. (2008) *"Planar array stack design aided by rapid prototyping in development of air-breathing PEMFC". Journal of Power Sources*, Volume 179, Issue 1, Pages 147-154.

Chowdhury, H., Alam, F., Mainwaring, D., Beneyto-Ferre, J. and Tate, M. (2012) *"Rapid prototyping of high performance sportswear", Procedia Engineering*, Volume 34, pp. 38–43. doi: 10.1016/j.proeng.2012.04.008.

Dickens, P. (2001) Rapid Manufacturing. In McDonald, J. A., Ryall, C. J. and Wimpenny, D. I. (eds). *"Rapid Prototyping Casebook"*. Trowbridge, Wiltshire: Professional Engineering Publishing Limited. Pages 239-247.

Kalpakjian, S. and Schmid, S. R. (2006) "*Manufacturing Engineering and Technology*". Fifth Edition. United States of America: Prentice Hall.

Kochan, A. (2000) *Rapid prototyping gains Speed, volume and precision. Assembly Automation",* Volume 20, Issue 4, Pages 295-299.

Muller, A. and Karevska, S. (2016) "*How will 3D printing make your company the strongest link in the value chain?*" Available at: http://www.ey.com/Publication/vwLUAssets/ey-global-3d-printing-report-2016-full-report/$FILE/ey-global-3d-printing-report-2016-full-report.pdf (Accessed on 17/10/2017).

Upcraft,S. and Fletcher, R. (2003) "*The rapid prototyping technologies. Assembly Automation",* Volume 23, Issue 4, Pages 318-330.

Vflash Brochure (2008). Available at: http://www.modelin3d.com/V-Flash_Brochure_NAV2.pdf (Accessed on 22/02/2008).

Yan, X. and Gu, P. (1996) *A review of rapid prototyping technologies and systems. Computer Aided Design",* Volume 28, Issue 4, Pages 307-318.

Zorriassatine, F., et al. (2003) *A survey of virtual prototyping techniques for mechanical product development. Engineering Manufacture"*, Volume 217, (Part B) Pages 513-530.

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Development of multi hazards map for Bangladesh using GIS technique

Monirul Islam
IUBAT – International University of Business Agriculture and Technology
Uttara, 1230

Mahfuzur Rahman
IUBAT – International University of Business Agriculture and Technology
Uttara, 1230

Xiaoying Li
Hohai University, Nanjing, Jiangsu

Nahidul Islam
IUBAT – International University of Business Agriculture and Technology
Uttara, 1230

ABSTRACT: *Bangladesh is one of the most disaster-prone areas in the world. Many different natural disasters – flood, cyclonic storms, tidal surges, droughts, tornadoes, riverbank erosion, earthquake, water contamination due to arsenic, etc. – occur in Bangladesh. Identifying the risk areas with reference to natural hazards causing damage to people of the country, the housing stock and the related infrastructure are most important for infrastructures development. In this study, using six of the most common natural hazards, namely earthquake, cyclones, tornadoes, drought, ground water arsenic and floods, we developed a hazard map using the country's 64 districts as geographic units. The hazard level is based on a combination of observed local hazard intensity, frequency of occurrences and vulnerability.*

This study assesses the relative threat, by district, of disasters in Bangladesh, and also the damages, history, severity of these areas, intensities of those natural disasters and housing vulnerability. GIS based disaster database is very crucial and an important aspect for environmental management strategy for planning and disaster mitigation, preparedness and preventive actions. This study prepared GIS based data sets which were used in the development of multi hazard zoning map. This multi-hazard zoning map will guide officials at the national and regional levels in the formulation of development strategies in multi-hazard active zones, land use management, revision and enforcement of appropriate codes and formulation of plans for mitigating measures against hazard risks affecting areas.

KEYWORDS: *Arsenic, drought, earthquake, flood, tornado, cyclone, multi hazard map, natural hazards*

Introduction

Bangladesh is one of the most disaster-prone areas in the world. Many different natural disasters – flood, cyclonic storms, tidal surges, droughts, tornadoes, riverbank erosion, earthquake, water contamination due to arsenic, etc. – occur frequently in Bangladesh. The 1988 flood killed 2389 people and nearly half of the population was affected (Islam & Sado 2002). The 1970 cyclone killed almost 500,000 people (Karim 1996). About 1300 people were killed by tornado at Saturia of Manikganj district in Bangladesh in 1989 (EIA 2004). The 1897 Great Indian Earthquake, with magnitude 8.7, was one of the most severe in the world; it killed 1542 peoples and affected almost the whole of the country (Oldham 1899). Crop and livestock losses were extremely high. Arsenic contamination of ground water in Bangladesh has emerged as perhaps the biggest natural calamity in the world. Arsenic concentrations in water samples taken from about half of the country's area are above the maximum permissible level of 0.05mg/l in Bangladesh. At least some people in 59 out of 64 districts are suffering due to the arsenic contamination in drinking water (Saifuddin and Karim, 2001). Among the major factors to explain the severity of disasters are flat topography, rapid run-off and drainage congestion of rain, low relief of the floods plains, low river gradients, heavy monsoon rainfall, and enormous discharges of sediments. The funnel shape and shallow depth of the Bay of Bengal increases the severity of cyclones. Cyclones and floods are the most damaging disasters in Bangladesh. But other disasters are also creating severe damage. Drought is recurrent in northern Bangladesh. It is causing permanent loss of agricultural production and desertification processes in some parts of North Bengal (Shahid and Behrawan, 2008). River erosion destroys thousands of hectares of land every year in a country where land is its scarcest resource. A future severe earthquake may cause billions of Taka worth of damage.

Earthquakes, cyclones, tornadoes, drought, arsenic contamination and floods arise from natural phenomena connected with the earth's interior and atmosphere, and they intersect the human environment. Geographic concentration of regular and frequent disasters impedes the overall socio-economic development efforts of the country (Haque 1997), as well as causing devastating loss of life, property, infrastructure and communities (Barua et al. 2016).

Some areas normally subjected to drought are in certain years subject to floods. Hazards like earthquakes, landslides, tornados, etc. occur suddenly, but their impact lasts over time. The extent of the impact of an earthquake depends on its magnitude; the impact of a tornado depends on wind speed, and the impact of a cyclone depends on wind speed as well as tidal height. The impact of arsenic depends on the ground water contamination level. Natural calamities may be broadly grouped into major and minor types depending upon their potential to cause damage to human life and property. Earthquakes, droughts, floods, tornadoes and cyclones can be regarded as major hazards. Landslides, riverbank erosion, groundwater contamination, fires, and tsunamis, whose impacts are localized and whose damage intensity is much less can be categorized as minor hazards. So far as damage to housing and infrastructure is concerned,

floods, cyclones, tornadoes and earthquakes are the four major disasters confronting the country.

The major disasters require disaster mitigation plans. Traditionally, many countries have been reactive to disasters. Adoption of the Hyogo Framework for Action, 2005–2015, by 168 countries has led to a paradigm shift, from emergency response to a comprehensive approach which, includes preparedness and preventive strategies to reduce risk. Early Warning Systems are well recognized as a critical life-saving tool for floods, droughts, storms and tidal storms, bushfires, and other hazards (WMO 2017). The World Meteorological Organization has suggested developing multi-hazard risk assessment techniques for early warning systems that reduce loss of life and property.

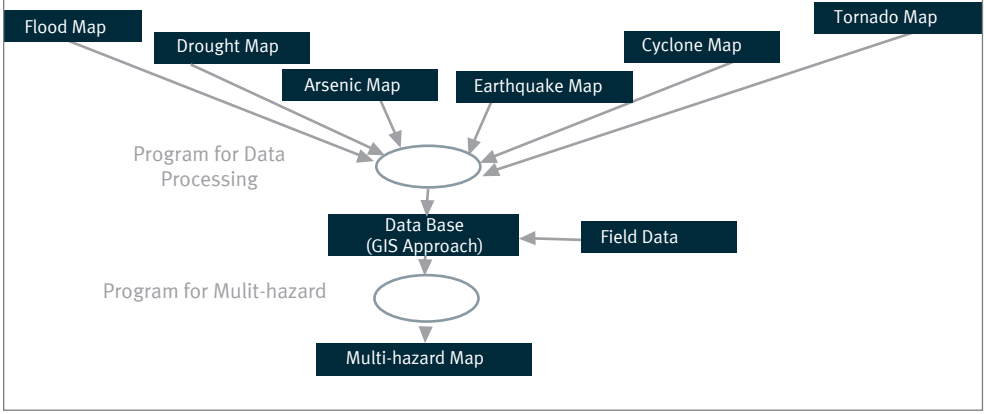
Multi-hazard maps are a practical tool in disaster mitigation planning and design of structures because they provide guidance when it is not feasible to do an assessment at particular sites. These maps give a good indication on the geographic distribution of expected high risk areas. This study identifies disaster-prone areas of Bangladesh and also history, damage severity and intensity of natural disasters. The GIS disaster database is an important source for developing an environmental management strategy. The information will assist engineers, architects, agriculture and fisheries specialists, and policy makers in mitigation planning for Bangladesh. This study will guide officials in land use management, revision and enforcement of appropriate building codes, and formulation of plans for mitigating measures.

Methodology

Preparation of the Data for the Study

We have explored historical disaster events, their duration, and information on the damages arising. We have also relied on GIS, a powerful planning tool to identify disaster-prone areas. Disaster data were collected from different organizations and sources. The maps for cyclone, earthquake, drought, arsenic, flood and tornado have been prepared by different organizations, such as Bangladesh Meteorological Department (BMD), Bangladesh Space Research and Remote Sensing Organization (SPARRSO), Disaster Management Bureau (DMB) and concerned non-government organizations (NGOs), Cyclone Preparedness Programme (CPP), and the Geological Survey of Bangladesh (GSB). Moreover, information from local and environmental organizations, and international journals was gathered for this study. Further, the disaster data were analyzed and compared with zoning maps. The zoning maps for individual disasters were digitized and converted to geo-referenced maps separately. Then the data were converted into GIS and finally superimposed onto the base map. The location, type, year and damages were digitized to put the database into the GIS system. The available historical data gathered from different sources for the disaster-prone areas of Bangladesh have been identified through GIS-based analysis and finally a multi-hazard map has been prepared. The schematic concept of the model we developed is shown in Fig. 1.

Figure 1: Schematic concept of a model for multi-hazard assessment



Estimation of risk score for natural hazard

The "hazard factor" for a particular hazard in a particular district was defined by comparing the district-wide historical disaster database with the corresponding intensity scales and damage risk levels (Barua et al., 2016). Hazard factors were considered on a scale from 1 to 3 for arsenic, 1 to 7 for drought, 1 to 8 for earthquake, 1 to 7 for flood and 1 to 8 for cyclone and 1 to 5 for tornado. "Weighting factors" for particular hazards in a particular district were defined based on the frequency of particular disasters in different districts. This employed a relative priority scoring system (higher scores for higher hazard-prone areas), where the base point is considered 1.0 for locations with no occurrence of a particular disaster; increases in frequency of disasters add 0.1 point (NOAA, 2007).Weighting factors for earthquake, flood, tornado used the suggested values assigned by Barua, et al. (2016). Weighting factors for arsenic and drought were also suggested in this paper. Weighting factors for earthquake and cyclone were revised on the basis of the new earthquake map suggested in the Bangladesh National Building Code (BNBC, 2015) and the frequency of occurrences of earthquakes and cyclones. Table 1 shows the hazard factor and weighting factor for each category of the hazards assessed (arsenic, drought, earthquake, flood, cyclone and tornado). The estimated hazard intensity, hazard factor and weighting factor for each type of hazard for each district are shown in Table 2. Hazard factors were considered on the scale from lowest to the highest value, where lowest value was assigned for zones with no hazards and the highest value for highly hazardous zones. Thus, the total hazard score from an individual hazard event (such as

a cyclone) could affect the multi-hazard total score for any district of the county. For each district of Bangladesh the hazard scores for arsenic, drought, earthquake, flood, tornado and cyclone are calculated (see Table 2). Adding those scores, after multiplying by weighting factor, yields the total risk score for each of the 64 districts, as expressed in equation 1.

$$HS = \sum_{k=1}^{n} (\mathbf{HFxWF}) \qquad (1)$$

Where, HS: total hazard score, WF: weighting factor, k=1 for arsenic, k=2 for drought, k=3 for earthquake, k=4 for flood, k=5 for cyclone, k=6 for tornado, and k=n (n: totalnumber of disasters) disaster. In these equations, two of the hazards have locations with a risk score of 0 (Cyclone and Tornado).

Table 1: Hazard factor and weighting factor for the calculation of multi hazard score

(a) For Arsenic, drought and earthquake

Arsenic			Drought			Earthquake		
	HF	WF		HF	WF		HF	WF
Arsenic not found	1	1	No drought	1	1.25 to 1.80	Low	1	1.1 to 1.7
Arsenic found	2	1.25	Low	2		Moderate	2	
Arsenic and patient found	3	1.5	Moderate	3		Severe	5	
			Severe	5		Very severe	8	
			Very severe	7				

(b) For flood, cyclone and tornado

Flood			Cyclone			Tornado		
	HF	WF		HF	WF		HF	WF
No flood	1	1 to 1.7	No cyclone	1	1.0 to 1.8	No Tornado		1.1 to 1.8
Low	2		Moderate	2		Moderate	2	
Moderate	4		Severe	5		Severe	3	
Severe	5		Very severe	8		Very severe	5	
Very severe	7							

Table 2 Total hazard score for individual districts of Bangladesh for multi-hazard events (WF: Weighting Factor, HF: Hazard Factor and HR: Hazard Rank)

District Name	Arsenic		Drought		Earth Quake		Flood		Cyclone		Tornado		Multi Hazard	Hazard Rank
	WF	HF	WF	HF	WF	HF	WF	HF	WF	HF	WF	HF	Total Score	HR
Panchagar	1	1	1.49	7	1.1	2	1.2	1	1	1	1.1	2	18.03	2
Thakurgaon	1	1	1.49	7	1.1	2	1	1	1	1	1	2	17.63	2
Nilphamari	1	1	1.49	5	1.1	1	1.5	5	1	1	1.2	2	20.45	2
Lalmonirhat	1.2	1	1.49	5	1.3	5	1.4	5	1	1	1.2	2	25.55	3
Kurigram	1.2	1	1.49	5	1.6	8	1.7	7	1	1	1.1	2	36.55	4
Rangpur	1.2	1	1.49	5	1.3	5	1.6	5	1	1	1.4	3	28.35	3
Dinajpur	1	1	1.49	5	1.1	2	1.3	4	1	1	1	1	17.85	2
Gaibandha	1	1	1.49	3	1.5	5	1.6	5	1	1	1.4	3	26.17	3
Joypurhat	1.2	1	1.49	3	1.3	2	1.3	2	1	1	1	1	12.87	1
Naogaon	1	1	1.49	5	1.2	2	1.6	4	1	1	1	1	19.25	2
Bogra	1.2	5	1.49	2	1.4	5	1.6	5	1	1	1.1	2	27.18	3
Nawabgonj	1.6	5	1.49	7	1.1	1	1.5	4	1	1	1	1	27.53	3
Rajshahi	1.4	5	1.49	5	1.2	1	1.5	4	1	1	1.1	2	24.85	3
Natore	1.4	3	1.49	2	1.2	2	1.6	5	1	1	1	1	19.58	2
Serajgonj	1.3	3	1.64	2	1.3	5	1.6	5	1	1	1.4	3	26.88	3
Pabna	1.6	5	1.64	2	1.3	2	1.6	5	1	1	1.2	2	25.28	3
Kushtia	1.6	5	1.64	2	1.2	2	1.2	2	1	1	1.2	2	19.48	2
Meherpur	1.5	5	1.64	5	1.2	1	1.1	1	1	1	1.1	2	21.2	2
Chuadanga	1.5	5	1.64	2	1.1	1	1.1	2	1	1	1	1	16.08	1
Jhenaidah	1.5	1	1.64	2	1.1	1	1	1	1	1	1	1	8.88	1
Magura	1.5	5	1.64	2	1.2	1	1.5	4	1	1	1.2	2	21.38	2
Jessore	1.5	5	1.64	2	1.1	1	1.1	1	1	2	1.2	2	17.38	2
Narail	1.4	3	1.64	2	1.2	1	1.6	4	1	2	1.4	3	21.28	2
Satkhira	1.5	5	1.64	2	1.1	1	1.1	1	1.2	5	1	1	19.98	2
Khulna	1.4	5	1.64	2	1.1	1	1.2	1	1.3	8	1.3	3	26.88	3
Bagerhat	1.6	5	1.64	2	1.1	1	1.3	1	1.2	5	1.2	2	22.08	2
Rajbari	1.4	5	1.64	2	1.3	2	1.6	5	1	5	1.1	2	28.08	3
Faridpur	1.6	5	1.64	3	1.2	2	1.6	5	1	2	1.5	5	32.82	4
Shariatpur	1.5	1	1.64	2	1.2	2	1.6	5	1	2	1.3	3	21.08	2
Madaripur	1.5	5	1.64	3	1.2	2	1.6	5	1	2	1	2	26.82	3
Gopalgonj	1.4	5	1.64	3	1.2	1	1.6	4	1	2	1.3	3	25.42	3

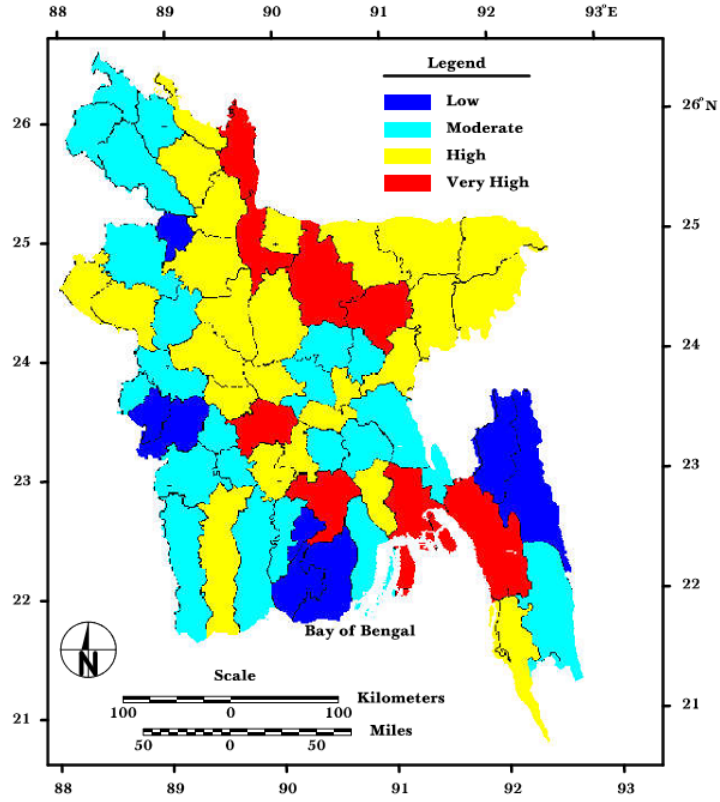
Barisal	1.5	5	1.64	5	1.2	1	1.6	4	1.6	8	1.3	3	40	4
Perojpur	1.4	1	1.64	5	1.2	1	1.2	2	1	2	1	2	17.2	2
Jhalakhati	1.4	1	1.64	5	1.2	1	1.1	1	1	2	1	1	14.9	1
Patuakhali	1	1	1.64	3	1.2	1	1	1	1.3	5	1	1	15.62	1
Barguna	1.2	1	1.64	3	1.2	1	1.2	1	1	5	1	1	14.52	1
Bhola	1.2	1	1.64	3	1.2	1	1.4	4	1.2	5	1.2	2	21.32	2
Sherpur	1.3	3	1.80	2	1.7	8	1.6	4	1	1	1.1	2	30.7	3
Jamalpur	1.3	5	1.80	3	1.7	8	1.7	4	1	1	1.4	3	37.5	4
Mymenshing	1.3	3	1.80	2	1.4	8	1.7	4	1	1	1.8	5	35.5	4
Netrokona	1.4	3	1.80	2	1.7	8	1.6	4	1	1	1.1	2	31	3
Kishoregonj	1.4	3	1.25	2	1.4	8	1.7	5	1	2	1.5	5	35.9	4
Sunamgonj	1.4	3	1.25	1	1.6	8	1.7	7	1	1	1	1	32.15	3
Sylhet	1.4	1	1.25	1	1.6	8	1.7	7	1	1	1	1	29.35	3
Moulvibazar	1.3	1	1.25	1	1.6	8	1.7	7	1	2	1.1	2	31.45	3
Habigonj	1.4	1	1.80	1	1.4	8	1.7	7	1	1	1	1	28.3	3
Tangail	1.3	3	1.80	5	1.3	5	1.7	5	1	1	1.2	2	31.3	3
Manikgonj	1.3	5	1.80	2	1.2	2	1.6	4	1	2	1.4	3	25.1	3
Gazipur	1.2	1	1.80	2	1.3	2	1.6	4	1	1	1.4	3	19	2
Norshingdi	1.3	1	1.80	2	1.2	5	1.6	5	1	2	1	1	21.9	2
Dhaka	1.2	1	1.80	1	1.2	2	1.6	5	1	2	1.8	5	24.4	2
Narayangonj	1.6	5	1.80	2	1.1	2	1.6	5	1	2	1.1	2	26	3
Munshigonj	1.4	5	1.80	2	1.2	2	1.5	5	1	2	1.2	2	24.9	3
Bramanbaria	1.6	3	1.80	1	1.2	5	1.6	7	1	1	1	3	27.8	3
Comilla	1.3	5	1.25	1	1.2	2	1.5	4	1.1	2	1.4	2	21.15	2
Chandpur	1.5	5	1.25	1	1.2	2	1.7	5	1.1	2	1.1	2	24.05	2
Lakshmipur	1.6	5	1.25	2	1.1	2	1.5	4	1	5	1.1	2	25.9	3
Noakhali	1.6	5	1.80	2	1.1	2	1.4	4	1.5	8	1.6	5	39.4	4
Feni	1.6	3	1.25	2	1.1	2	1.4	4	1.1	5	1.1	2	22.8	2
Khagrachari	1	1	1.25	1	1.2	5	1	1	1	2	1	1	12.25	1
Rangamati	1	1	1.25	1	1.2	5	1.1	1	1	2	1	1	12.35	1
Chittagong	1	3	1.25	2	1.2	5	1.5	7	1.8	8	1.1	2	38.6	4
Bandarban	1	1	1.25	1	1.3	5	1.2	4	1	2	1	1	16.55	2
Cox`s Bazar	1	1	1.80	1	1.2	5	1.3	4	1.7	8	1.1	1	28.7	3

Table 3 Hazard index and risk score

SN	HI	THS	Area (%)	Hazardous Districts
1.	Low	<17	12	Joypurhat, Chuadanga, Jhenaidah, Jhalakhati, Patuakhali, Barguna, Khagrachari, and Rangamati
2.	Moderate	17-24	34	Panchagar, Thakurgaon, Nilphamari, Dinajpur, Naogaon, Natore, Kushtia, Meherpur, Magura, Jessore, Narail, Satkhira, Bagerhat, Shariatpur, Perojpur, Bhola, Gazipur, Norshingdi, Dhaka, Comilla, Chandpur, Feni, and Bandarban
3.	High	25-32	38	Lalmonirhat, Rangpur, Gaibandha, Bogra, Nawabgonj, Rajshahi, Serajgonj, Pabna, Khulna, Rajbari, Madaripur, Gopalgonj, Sherpur, Netrokona, Sunamgonj, Sylhet, Moulvibazar, Habigonj, Tangail, Manikgonj, Narayangonj, Munshigonj, Bramanbaria, Lakshmipur, and Cox`s Bazar
4	Very High	>32	16	Kurigram, Faridpur, Barisal, Jamalpur, Mymenshing, Kishoregonj, Noakhali, and Chittagong

HI:Hazard index, TRS=Total hazard score

Figure 2: Mulit-hazzard Map



District wise multi-hazard map

We prepared a multi hazard map (see Figure 2) using the total hazard district-level scores estimated in Table 2. The hazard levels were categorized as follows: low total score <17, moderate 17-24, high 25-32, and very high >32. This map shows the hazard scenario of Bangladesh at a glance. Table 3 lists the districts corresponding to each multi-hazard zone. The total area of districts in very high hazard zone is 16%. Districts in the high hazard zone cover 38%; districts in moderate and low hazard zones cover 34% and 12%, respectively.

Conclusions

Bangladesh is undeniably a disaster-prone country. The prime objective of this study is to identify the particularly vulnerable areas due to natural hazards arising from arsenic, drought, earthquakes, floods, cyclones and tornadoes. In this study, a complete data base has been prepared and all required maps have been developed in digital form, which can be used as a GIS database in other fields. The district-wide multi-hazard scores were calculated from the risk and weighting factors. By using this multi-hazard score to rank districts, we prepared a zoning map. The results described in this study should provide helpful information about disaster management strategy for planning and disaster mitigation, preparedness and preventive actions, and should be useful in assigning priority for mitigating development in very high and high hazard zone.

References

Barua U, Akhter MS and Ansary MA (2016). District-wise multi hazard zoning of Bangladesh, Nat. Hazards, DOI 10.1007/ s11069-016-2276-2.

Haque CE (1997) Atmospheric hazards preparedness in Bangladesh: a study of warnings, adjustments and recovery from the April 1991 cyclone. Nat Hazards 16:181-202.

IAEE (1981). A manual of earthquake resistant non-engineered construction, International Association of Earthquake Engineering.

International Conference on Environment Science and Engineering, IPCBEE vol.8 (2011) © (2011), IACSIT Press, Singapore.

Islam, M. M. and Sado, K. (2002). Development priority map for flood counter measure by remote sensing data with geographical information system, Journal of Hydrologic Engineering, JSCE, 7(5), 346-355.

Oldham T (1899). Report on the Great Indian earthquake of 12th June, 189. Mem Geol Surv India 29:1-349.

Shahid S. and H. Behrawan (2008) Drought risk assessment in the western part of Bangladesh, Nat. Hazards, vol. 46(3), pp. 391-413, doi: 10.1007/s11069-007-9191-5.

WMO (2017), http://www.wmo.int/ pages/prog/ drr/projects/Thematic/ MHEWS/ MHEWS_ en.html ©2017 World Meteorological Organization, 7bis, avenue de la Paix, CP No. 2300, CH-1211 Geneva 2, Switzerland.

Tributes to the founder of IUBAT

Dr. M. Alimullah Miyan - Visionary and Pioneer of Private Universities

Professor Dr. Abdur Rab

The day was like any other in 1988. A group of 10-12 people entered the brick-wall, tin-roof restaurant. Minutes later, came the sound of breaking chairs, tables and glasses, as well as a hue & cry. People dashed out of the restaurant and ran away. There was an 'all quiet' in the restaurant. About an hour later, leaders of a mob chanted very loud slogans calling on their followers to attack the restaurant, which was stormed with pebbles and bricks from three sides – a three-pronged attack by hundreds of people. Several rounds of gun shots came from inside the restaurant. Despite this, the mob marched on and got closer to the restaurant. Suddenly, people came out of the restaurant and tried to run away. But in vain. One by one they were chased, caught and beaten. Then the attackers helped the injured onto rickshaws and paid the rickshaw pullers – perhaps to take them to a hospital. The attackers entered the restaurant as victors and soon it was humming with loud voices and laughter.

From the second floor of a building adjacent to the restaurant, two professors observed the scene with despair. Their institution was closed and nobody knew when it would reopen. One professor asked the other, "when will student unrest and university closures come to an end, and a normal learning environment prevail?" 'Never", replied the other; "political parties will never cease to use the students for their partisan benefit."

The conversation continued.

Professor A: *"Does this kind of unrest take place in the non-government colleges?"*

Professor B: *"There are very few such incidents in non-government colleges."*

Professor A: *"How about private universities?"*

Professor B: *"What private universities?"*

Professor A: *"Interesting question. I don't know either, but let us find out."*

They pulled up a list of universities in Bangladesh and, to their surprise, learned that there were no non-government universities in the country. University of Dhaka was established in 1921, Rajshahi University in 1953, Bangladesh Agricultural University in 1961, Bangladesh University of Engineering (BUET) in 1962, Chittagong University in 1966, Jahangir Nagar University in 1970, and so on. Each government university was established under a separate act.

Professor A: *" There are many private colleges. Why is there no private university?"*

Professor B: *"Perhaps because setting up a university requires a huge investment. Or maybe, no one thought to do it."*

Professor A: *"Well, we can think of doing it! There is no law preventing us. Let's set up such a university."*

The restaurant in this story was Modhu's Canteen in the Arts Faculty campus of Dhaka University in Nilkhet, the famous Canteen where the language movement meeting was held in 1952. At the time, it was located where the emergency block of the Dhaka Medical

College is now standing. The Canteen is an important institution in the history of Bangladesh; it is where many political movements originated, including discussions leading up to the Bangladesh liberation movement.

The adjacent building is home of the Institute for Business Administration (IBA) at Dhaka University. Professor (A) was Dr. M. Alimullah Miyan; professor (B) was me. We were colleagues at IBA and worked together on research studies, training programs – and the private university project. We organized several meetings on how to proceed. First of all, we wanted to know how such universities have been set up and managed in other countries – particularly in our neighboring countries. We found that there were no private universities in SAARC countries.

We got an opportunity to observe and study how American universities are managed under a World Bank Fellowship. Dr. Miyan went to Kansas State University, and I to Michigan State University. Dr. Miyan asked me to look for and visit one or more private universities in Michigan and learn how they were set up and managed. He asked me to collect whatever documents on administrative matters were available. While staying in Michigan, I came to know the University of Michigan as one such university. I visited and discussed with its Vice President (Administration). I collected documents and brought them to Dhaka. Dr. Miyan actually signed a cooperation agreement with Kansas State University to assist in the process of setting up a university. In the last leg of my visit to US, I had an opportunity to visit the University of New Brunswick in Canada to explore potential collaboration with IBA. Nearby, I found a small private university, founded by a Catholic order, which offers liberal arts undergraduate degrees. It did not fit the kind of university we were planning.

We came home and shared our experiences. One day, Dr. Miyan called me to see him immediately: "You said there are only public universities in Bangladesh. But I noticed the sign board of Darul Ihsan University in Dhanmondi, which is not a public university'. I was surprised. After his visit, he reported that Darul Ihsan University offers Masters level courses and, under an agreement, the degree is granted by Mecca University.

Another aspect was simply a lack of university seats. Every year, after admission tests of the public universities, we received calls from friends, relatives, colleagues and alumni: their children, although good students, could not get admission. When parents could afford overseas education, their sons studied in UK, US, Australia, Thailand, Malaysia, and India. In India alone there were 32,000 Bangladeshi students studying in schools, colleges and universities. But many parents of daughters would not send their daughters abroad for higher education. There was a serious need for alternatives to public universities. The case for non-government universities became obvious.

First, we had to choose a name. We finally settled on 'University of Business, Agriculture and Technology'. No country can prosper without business and, as business teachers, we had a preference for this discipline. However, we also concluded that education and research in agriculture (specially research in rice cultivation) were crucial for a country with a growing population and a need to enhance food production. Also important is promotion of new technology to increase productivity and

the ability of Bangladesh to compete with other nations. We later added 'international' to address the emerging issues of globalization. The name reflected our ideas about the university's vision, mission, values and strategies. When it came to choosing a logo, we used the first two letters of Indiana University (IU), where both of us had earned MBA degrees.

The next task was selecting degrees and programs , and designing curricula. Dr. Miyan requested that I design the Bachelor of Business Administration (BBA) and Masters (MBA) curricula. A Rotary friend of Dr. Miyan, an engineer, designed the initial engineering program. Another friend of Dr. Miyan, a professor of Bangladesh Agricultural University, designed the agriculture program. After designing the draft BBA curriculum, we organized a seminar attended by business educators and management professionals for review. Attendance in the seminar exceeded our expectations; the auditorium of the Planning and Development Academy in Nilkhet was full. We received many practical suggestions, which we incorporated in the final BBA curriculum. Thus was born the first BBA curriculum in the country. Later, it was adopted by IBA and other universities.

We projected student numbers and manpower needs. We also prepared job descriptions for each position. The university was initially located in Dhanmondi in a rented building. Only later, the university moved to its permanent campus in Uttara. We attended to details such as classroom furniture. We made a financial projection to determine the level of tuition fees. The fees had to cover all costs and leave a surplus for future development of the university. We estimated total fees of Tk. one lakh per year for the BBA. Fees for other programs reflected additional cost involved.

Dr. Miyan met with the Secretary of the Ministry of Education and presented the project. He acknowledged that it was an impressive case, and that he would present the file to the Minister of Education with a strong positive recommendation. Before the week was out, the Secretary called Dr. Miyan to his office. The Minister had showed interest, but finally did not approve the project. Disappointed but not discouraged, Dr. Miyan told me, "This government may not agree but the next government will agree." I was less optimistic: "There is no sign of change of government." He replied, "You never know when and how governments will change in this country … Change may be very near."

One day he asked me, "Do you know anybody who can arrange a meeting for us with the leader of one of the two opposition political parties?" I had a student related to the General Secretary of one of the parties. I contacted the student and his relative arranged a dinner party with the party leader. We had a brief meeting with her, and she was favourable. She invited us to meet her party secretary in charge of education. Dr. Miyan met him and was reassured: since his party leader had accepted the idea, it would be considered positively if and when his party came to power. However, Miyan reported, we do not know who next will come to power. So, Dr. Miyan went to meet the leader of the other major party. He reported back that she too was positive, although she had a preference for public universities.

Two years later, the the first leader we met came to power and the party secretary in charge of education became the Education

Minister. Dr. Miyan managed to meet him the day after he was sworn in as Minister. A lawyer by profession, the Minister reassured Miyan that he would enact a law enabling private universities so that our proposed university would have a legal foundation. He asked the Education Secretary to take necessary action. He in turn replied that the Ministry of Law must draft the law, which may cause delay. Dr. Myian volunteered that he had already drafted a law, which may speed up the process. He handed the draft to the Secretary. Meanwhile, a former minister of education, a former secretary, and others joined the movement for private universities. The ball had started rolling. In 1992, The Private Universities Act was passed. Dr. Miyan's vision became a legal reality.

While he pursued a legislative foundation, Dr. Miyan did not wait for the vagaries of change of government and passage of legislation. He went ahead to set up the university. By 1990, he had signed an agreement with Assumption University in Bangkok to mount Business and Computer Programs via IUBAT. If there was no legislation, students would receive their degree from Assumption. When IUBAT classes started in 1991, the first private university in Bangladesh became an actual reality. After passage of legislation, new private universities followed IUBAT's example. Subsequently, Pakistan, India, Sri Lanka and Nepal also followed. So, Dr. Miyan was not the visionary and pioneer of private universities in Bangladesh alone; he was the catalyst for private universities throughout SAARC countries.

— Prof. Dr. Abdur Rab
Vice Chancellor (Designatecd)
International University of Business
Agriculture and Technology
Former Professor and Director, IBA,
Dhaka University

Eulogy for Md. Alimullah Miyan, Ph.D.
Founding Vice-Chancelor IUBAT

I came to know Alimullah Miyan in 1992. He had recently resigned a prestigious academic position in the University of Dhaka and had launched IUBAT, the first Bangladesh university operating under legislation enabling non-government universities. At the time, he was touring Canadian universities to learn about university administration and to make connections. I hosted his visit to my university, Simon Fraser University in Vancouver. Knowing very little about Bangladesh but intrigued by his enthusiasm, I accepted an invitation to visit his home and his university. I have been visiting IUBAT ever since, at least once per year. I have come to know a little about Bangladesh; I have made friends, and I take the occasion of the second issue of the IUBAT Review to honour Miyan's contribution to higher education in his country.

Miyan could have enjoyed a comfortable life as an academic at the University of Dhaka; he and his family could have emigrated to a western country. He did neither. His ambition was to develop a credible university, free of partisan politics, that would contribute to the education of the next generation of Bangladeshi. He was among the generation of "social entrepreneurs" who founded and built major NGOs and education institutions in the two decades following the War of Liberation. They are now over 70 and some unfortunately have died. Miyan died in the spring of 2017.

When I first visited Dhaka, IUBAT occupied several floors in a rented warehouse in the Dhanmondi neighbourhood. As enrolment grew, IUBAT made use of every square meter in the building, including laboratories on balconies and Sheema's café on the rooftop. I followed the painfully complex negotiations with government authorities required to develop the present campus in Uttara. In the 1990s, Uttara was on the outskirts of metropolitan Dhaka; it has now grown to become a major community within metropolitan Dhaka. Simultaneously, IUBAT has grown; it now hosts 8000 students.

At times, Miyan and I disagreed on priorities for IUBAT. This is not the time to revisit our disagreements. This is an occasion to acknowledge the time and energy he devoted to building IUBAT – recruiting faculty, encouraging students, inviting foreigners (such as the Canadian nurses who helped build the nursing college), and protecting the university from those who did not wish it well. Many others have devoted nearly equivalent time and energy. At the risk of giving offence to others who have contributed much, I mention three people I have known well – pro-Vice Chancellor Mrs. Khanum, Selina Nargis who for the last decade has assumed a major role in university administration, and Rabiul Islam the VC's personal assistant.

The last request that Miyan made to me was that I serve as the "native English speaker" – I was born in England – and help edit the initial issues of this journal. The intent of the *IUBAT Review* is to provide a multidisciplinary outlet for articles of good quality written by, primarily, faculty at IUBAT. If we succeed in establishing the reputation of the journal, we will in a small way have advanced Miyan's mission.

We must hope that Bangladesh produces a new generation of "social entrepreneurs" with as much passion to advance the country as Miyan's "liberation war" generation.

— John Richards
Visiting faculty member

About IUBAT

International University of Business Agriculture and Technology (IUBAT University) is a government approved non-profit independent institution and its fundamental objective is human resource development through appropriate teaching, training and guidance as well as creation of knowledge conducive to socio economic development of developing societies in general and that of Bangladesh in particular. This objective is being attained through offering courses and curricula relating to various aspects of knowledge as well as providing opportunities for individuals to acquire skills and relevant experience in the chosen field of specialization, research, consultancy and training through specialized Centers.

IUBAT University is approved by the Government of Bangladesh as a degree granting institution under the Non-Government University Act of 1992. IUBAT University curriculums have been approved by the University Grants Commission (UGC) of Bangladesh and vetted by cooperating universities abroad. The Bangladesh Public Service Commission accepts its academic standards.

IUBAT University operates as an international institution having linkages with 74 universities and institutions located in industrially developed and developing countries. The university is a member of Association of Commonwealth Universities, extending its recognition to all 34 Commonwealth countries including those in SAARC region. IUBAT University is also a member of a number of international scholarly bodies including Association of SAARC Universities, Those linkages with universities and networks enables IUBAT University to conduct international programs within the country and conduct programs internationally.

IUBAT University has more than180 Faculties (Professor, Associate Professor, Assistant Professor and Lecturer) in Different Disciplines/Programs. It has 80 officers (Registrar, Deputy Registrar, Assistant Registrar, Project Director, Deputy Director, Administrative officer, Accounts officer etc.) and 20 Staffs who represent different Department. As mentioned earlier, IUBAT University is organized into colleges, departments and centers for academic as well as service activities. There are nine specialized centers which carry out applied research, offer diplomas, certificate courses and professional consultancy services to clients as well as support to academic programs of IUBAT University colleges and departments.

IUBAT—International University of Business Agriculture and Technology

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