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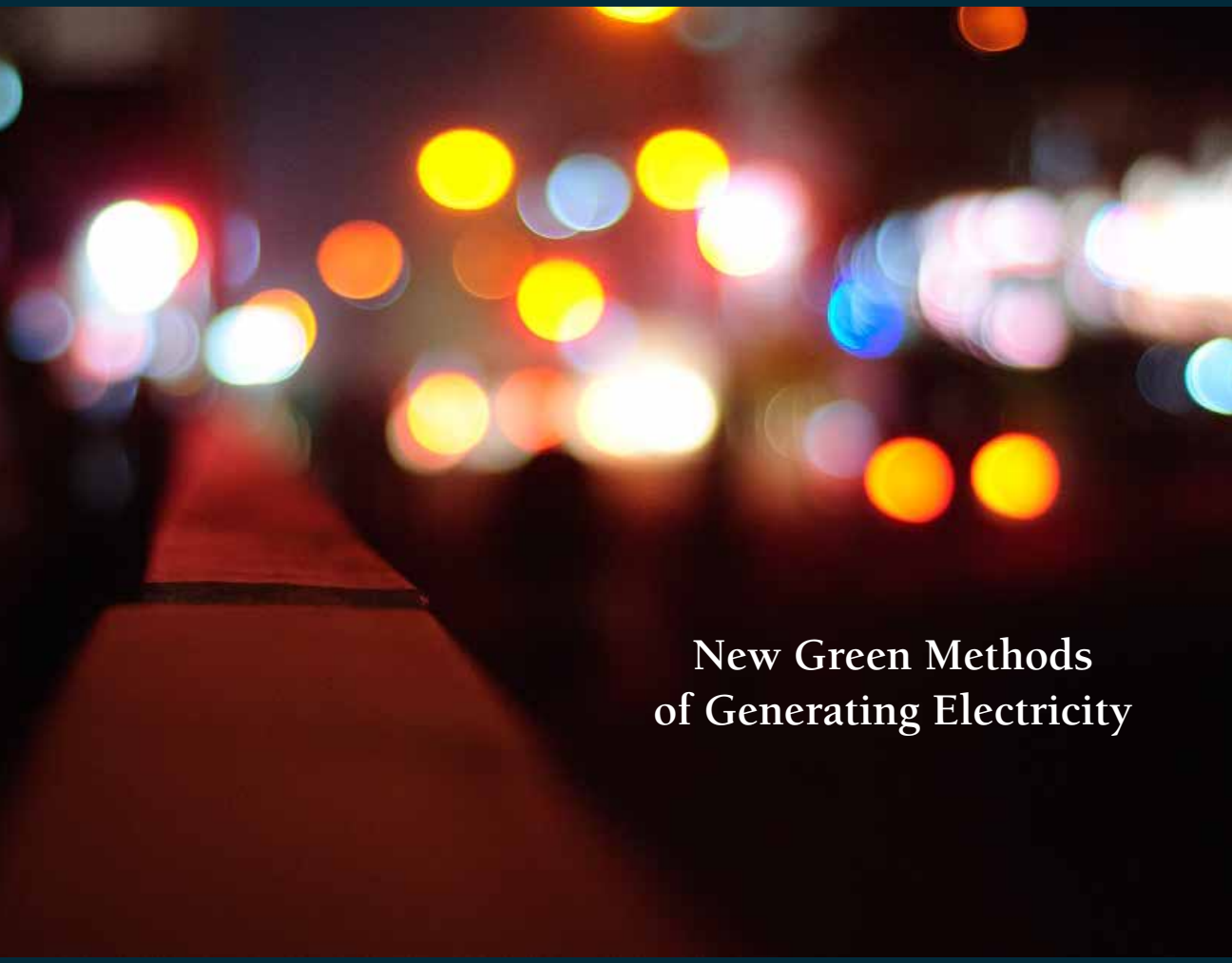

New Green Methods of Generating Electricity

International University of Business Agriculture and Technology

Front cover photo:
Dhaka at night, courtesy Sakib Iqbal

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Editor

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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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Razin Ahmed, Rezoana Arif, and Bishwajit Saha. 2016. "A Study on New Green Methods of Generating Electricity." *IUBAT Review* 1 (1): 6-12. iubat.edu/journal

A Study on New Green Methods of Generating Electricity

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ABSTRACT: *In this paper, a new method of electricity generation, namely geothermal technique based on carbon dioxide (CO_2), is proposed as a partial solution to the power generation needs of Bangladesh. This geothermal technique is an environmentally friendly and safe method of electricity generation compared to some other methods of power generation. Although the cost of the overall system is high, especially for storage of liquid CO_2 this high cost can be reduced by using multiple sub-systems of power generation. Every brick field can set up a CO_2 trap including a liquefied conversion unit. The pros and cons of the newly proposed method have been discussed extensively with some specific points related to environmental and technical issues. The overall results show that the new method can be useful in Bangladesh to generate an adequate supply of electricity to meet demand.*

KEYWORDS: *geothermal, renewable energy, CO_2 emissions, CO_2 conversion.*

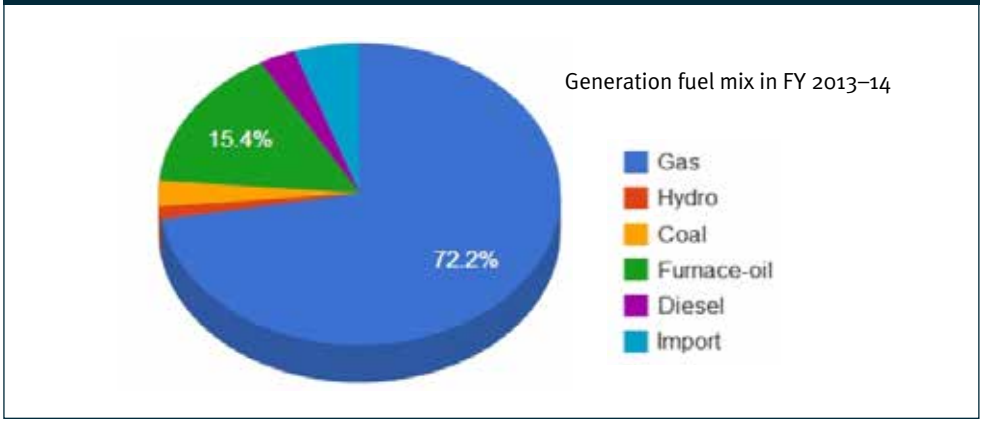
Introduction

BANGLADESH IS IN GREAT NEED of more electricity generation capacity for its economic growth. The country has small reserves of oil and coal, and very large natural gas resources. In Bangladesh the primary source of commercial energy is natural gas (72%), followed by oil, hydro power, and coal. Natural gas comprises around 82% of the energy source for electricity generated (IEA 2008; Rifatand Islam 2014; Flavin and Aeck 2005). At present, the Government of Bangladesh and private firms are trying to develop fossil fuel power stations, nuclear power stations, renewable energy systems, and so on. However, fossil fuel power stations inevitably cause environmental pollution. The renewable systems do not generate greenhouse gases, but they create other problems. Typically they have higher generating costs per MWh of electricity. Many renewable technologies are intermittent and pose problems of storage if they are to generate base power.

While Bangladesh has considerable gas reserves, this is a finite resource and annual consumption is rising rapidly (Ullah, Hoque and Hasib 2012, 618-627). At present, 53% of the total electricity generation of Bangladesh comes from power plants under the public sector and 47% is added from the private sector (Nasrin 2013). Despite a tripling of maximum generation capacity from 2100 MW in 1995–1996 to 6200 MW in 2011, there remains a power crisis in the country (Anam et al. 2011, 13; Government of Bangladesh 2011, 1-2). Because of the shortage of gas supply, some power plants are unable to produce power at their rated generation capacity. The power crisis has other aspects: exhaustion of fossil fuel reserves, deforestation, and environmental pollution (Anam and Al-Bustam 2011).

Geothermal technology uses deep-earth heat to generate electricity. Currently, geothermal plants rely on locations where hot water is trapped under the surface, and can be pumped out to drive turbines. This method of generating electricity limits the feasible locations (Lepisto 2007).

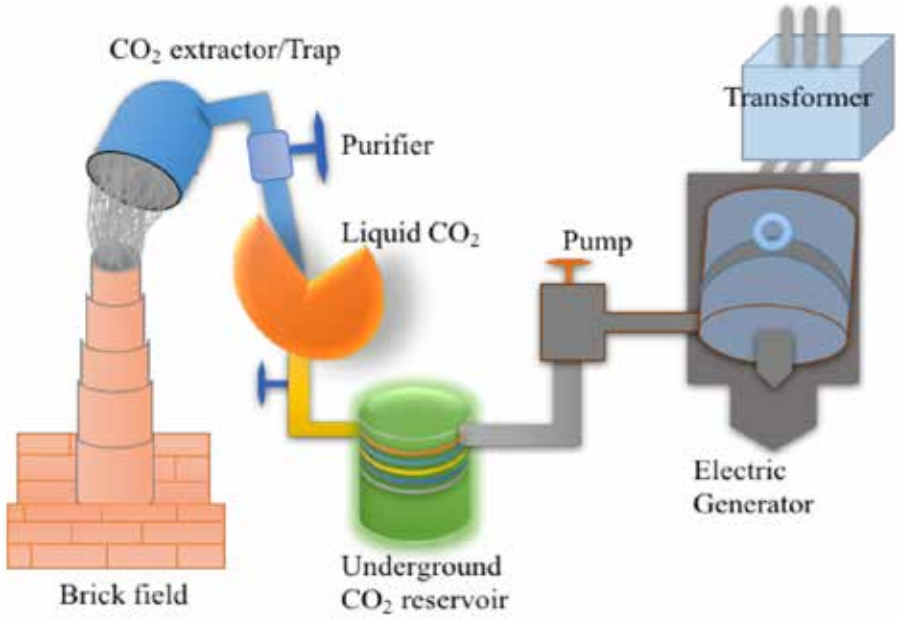
Figure 1: Net Energy Generation (%) by Different Resources (Renewable Energy in Bangladesh)



This paper presents a new method of environmentally friendly electricity generation. In Bangladesh, there are uncounted brick fields that generate huge amounts of carbon dioxide (CO_2) every day. This new method collects the CO_2 from the chimneys of brick fields and stores CO_2 inside the earth surface. The storage CO_2 drives turbines to generate electricity. Figure 2 shows a schematic diagram of electricity generation using CO_2 emissions.

Figure 2: Schematic View of Generating Electricity Using Carbon Dioxide of Brick Fields

Carbon dioxide (CO_2) is captured at the source from fossil fuel burning brick fields. The collected CO_2 is liquefied and stored efficiently in a reservoir. In order to use this CO_2, a pump feeds into the generators. The whole procedure is called a carbon dioxide storage and electricity generation system (CSEGS). Carbon dioxide flows through the porous rock bed deep in the earth more quickly than water. Moreover, the CO_2 expands more significantly than water when it is heated, thus the pressure differential between the CO_2 pumped into the ground and this heated CO_2 is much greater than the pressure differential of the water for the same procedure.



Feasibility of New Method in Bangladesh

Bricks are one of the basic building components in Bangladesh. From the brick fields, CO_2 can be collected easily, and can be used instead of water for geothermal electricity generation. Simultaneously, CO_2 emissions can be reduced and the power crisis relieved. The cost of collection and storage of CO_2 and the cost of a geothermal turbine remain to be calculated.

According to studies, the cost of a new geothermal power plant is higher than that of a comparable natural gas facility. While the construction costs of a natural gas plant are lower than for a geothermal plant, operating costs of a natural gas facility are higher than for a geothermal plant. The levelized cost per MWh of geothermal power are in the range of Tk. 8,000 per MWh. While this is higher than the levelized cost per MWh of natural gas, it is similar to that of other renewable and nuclear power costs (Geothermal Energy Association 2016).

An advantage of CO_2 over water-based geothermal power is that the CO_2 expands so much that the pressure alone can carry the heated CO_2 back to the surface. (This effect is referred to as the thermo-siphon.) The thermo-siphon makes the use of pumps for recovering the hot CO_2 unnecessary (Lepisto 2007). For instance, the California Energy Commission (CEC) undertook cost estimation for a 50 MW geothermal binary plant and 50 MW dual flash geothermal power plants. The CEC found that the levelized cost per MWh of a geothermal binary plant would be Tk. 7360 and of a dual flash geothermal plant Tk. 7040. These estimates imply that the plants could be competitive with various other technologies, including natural gas technology.

According to the CEC report, the cost per megawatt hour for a 500 MW combined cycle natural gas plant is Tk. 8080. The capital cost per megawatt for a 100 MW simple cycle plant is Tk. 46880. According to a 2006 report, the capital cost estimate for a new geothermal plant (together with the production tax credit) ranged from Tk. 48000 to Tk. 64000 per MW. However, it should be recognized that the cost for a geothermal project can vary significantly based upon factors such as local, regional, national, and global availability of commodities and that costs change over time with economic conditions (Geothermal Energy Association 2016).

Table 1 sets out the amount of electricity generated in Bangladesh from 1995 to 2011 (Anam et al. 2011, 13; Rahman 2011, 9).

Maximum Electricity Generation Capacity (MW)	
1995–1996	2087
1996–1997	2114
2001–2002	3218
2002–2003	3458
2003–2004	3622
2004–2005	3751
2005–2006	3812
2006–2007	3718
2007–2008	4230
2008–2009	4037
2009–2010	4606
2010–2011	4699

Advantages and Disadvantages

In our country, water is abundant, and water-based geothermal power generation is perfectly feasible here. However, to reduce the excessive carbon dioxide emissions from the brick fields, the carbon dioxide geothermal process can play a vital role.

Environment Friendliness

Compared with power generation systems that use coal, natural gas, or other fuels, the footprint of geothermal power plants is smaller. The surface area occupied by a reservoir, pump house, heat exchanger, turbine hall, is much less than the area occupied by typical power generating plants. Unlike other power plants, a geothermal plant does not require miles of gas or fuel pipe lines. This kind of power plant requires only proper geothermal hot water, which is usually available at the site.

If the gases, extracted from the brick houses in Bangladesh, can be converted to liquid and piped at the injection pit to magma below the earth's surface, this will purify the air. Some geothermal resources may be near forested regions, and the combined brick house and geothermal power station setup may deforest the region. But other types of power stations also would do so. A geothermal power plant is more reliable than conventional power plants.

While producing electricity, geothermal power plants, unlike other power plants, do not generate greenhouse gases. Hydrogen sulfide emitted from the geothermal power plant can be eliminated by a scrubber system. According to the Nevada Geothermal Council, almost 4.5 million tons of oil and 2.25 million tons of carbon dioxide are saved merely by 300 MW of geothermal power (Geothermal Energy Association 2012, 4).

Renewable

Currently, Bangladesh is in great need of more electricity for its growing population. To meet this additional demand in the context of "defossilization" of the world economy, the country needs plans for renewable electricity generation. As a riverine country, geothermal power generation may be the best renewable technology in practice. In the geothermal process, water is superheated by magma beneath the earth, and vapour from this hot water is used to turn turbines and generate electricity. Having passed through the turbine, condensed water is returned to magma rock level.

Solar power is a renewable technology. However, solar energy is not available at night or in dark or cloudy weather unless the energy has been saved in a storage device. The absence of large-scale storage remains a major obstacle to use of solar power for base load. With geothermal processes, there is no such difficulty, as hot water is always available.

Nuclear energy has contributed to non-fossil fuel power generation, but it creates difficulty in management of radioactive spent fuel (Nuclear Energy 2014).

Reliability and Simplicity

Geothermal power generation is the simplest power generating process, compared with other non-fossil fuel power generating technologies. It is the most feasible and most stable means of generating base load power. Once a geothermal power plant is set up, it is stable unless a heavy earthquake occurs.

Raw Material Availability

In a CO_2 geothermal process, the only raw material is CO_2, which can be collected from brick fields throughout the country and preserved in liquid form in drums or underground store rooms. Furthermore, the geothermal process is free from the transportation cost of coal or natural gas.

Sustainability and Cost of the System

If geothermal resources are used for power generation, Bangladesh fossil fuel resources will be preserved for other purposes. The major drawback to geothermal power is its high cost of plant construction. To date, the cost of geothermal capacity has been in the range of Tk. 160 million to Tk. 560 million per megawatt of capacity (Maehlum 2012). This is a cost well above most conventional power sources. However, as discussed above, the levelized cost per MWh is similar to other non-fossil fuel technologies such as nuclear. Carbon dioxide geothermal is obviously associated with hydrocarbon combustion and hence is associated with some activity generating greenhouse gases.

Noise, Hydrogen Sulphide and Loss of Forest

There is also the problem of noisy drilling processes, creating an inconvenience for religious practices, as well as and hydrogen sulfide gas emissions. In order to extract the hot water 4,000 meters below the earth surface, a production pit is created by means of drilling, which creates enormous noise pollution in the region of the geothermal power plant. This is an inconvenience for the dwellers and worshippers (Fridleifsson et al. 2008, 20-25). Hydrogen sulfide gas, from the superheated geothermal water, is released into the atmosphere when it turns into steam, which causes environmental hazards (Zorpette 1992, 49).

Despite all the controversies, it is clearly established that, except for the enormous capital construction cost, the geothermal process is a viable renewable power generation process in our country and can help meet our extreme need for electricity.

Conclusion

This article proposes a new method of generating electricity. The carbon dioxide storage and electricity generation system (CSEGS) could simultaneously supply more electricity for Bangladesh and help save the environment.

This method can be used in all industries where CO_2 is produced in large quantities. Storing liquefied CO_2 below ground is increasingly seen as a solution to generation of electricity as well as a means of reducing greenhouse gas emissions that contribute to global warming. In addition, CSEGS can be used in many locations around the country, unlike conventional geothermal electric plants.

CSEGS has advantages compared with other renewable energy systems that generate electricity from the sun or the wind. Energy generated from these sources is often wasted when demand does not equal supply. In contrast, CSEGS generation of electricity can be varied continuously.

This new geothermal process of electricity generation is under research and evaluation to verify its cost-effectiveness in Bangladesh.

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Under-Five Mortality

Comparing National Levels and Changes Over the Last Decade in South Asia and Other Low-income Countries

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ABSTRACT: *This article analyzes institutional factors associated with under-five mortality at two intervals (2000-03 and 2010-13) among low-income countries, with an emphasis on South Asia. The factors considered fall in four broad categories: health sector inputs (national per capita ratios of professional health care providers and hospital beds, plus public health spending as percent of GDP), performance of public health institutions (access to safe water and sanitary toilet facilities, child immunization, total fertility rate, and access to mosquito nets in malaria-prone countries), social determinants of health (female literacy, percent under $1.25/day and per capita GDP), and effectiveness of national governments in providing services. In explaining changes in mortality levels between decades, four factors are significant: increase in percent above $1.25/day, in vaccination rates and in rates of use of mosquito nets, plus average government effectiveness over the decade. In explaining mortality levels, the top quarter of countries ranked by under-five mortality outperform on average the comparable averages for the three other quarters on nine factors assessed. Achieving top-quarter mortality levels requires superior performance among most of the complex institutional factors such as schools and sanitary infrastructure.*

KEYWORDS: ***under-five mortality, governance, institutions, low-income countries, South Asia, Bangladesh***

IN THIS ARTICLE we assess factors associated with under-five mortality among a sample of 77 low-income countries, with an emphasis on six countries in South Asia.[1] We examine mortality levels at two intervals a decade apart: early in the 2000s immediately following launch of the Millennium Development Goals (MDGs) and the most recent data, covering years early in the present decade. The factors we consider as potentially explaining national mortality rates fall into four broad categories:

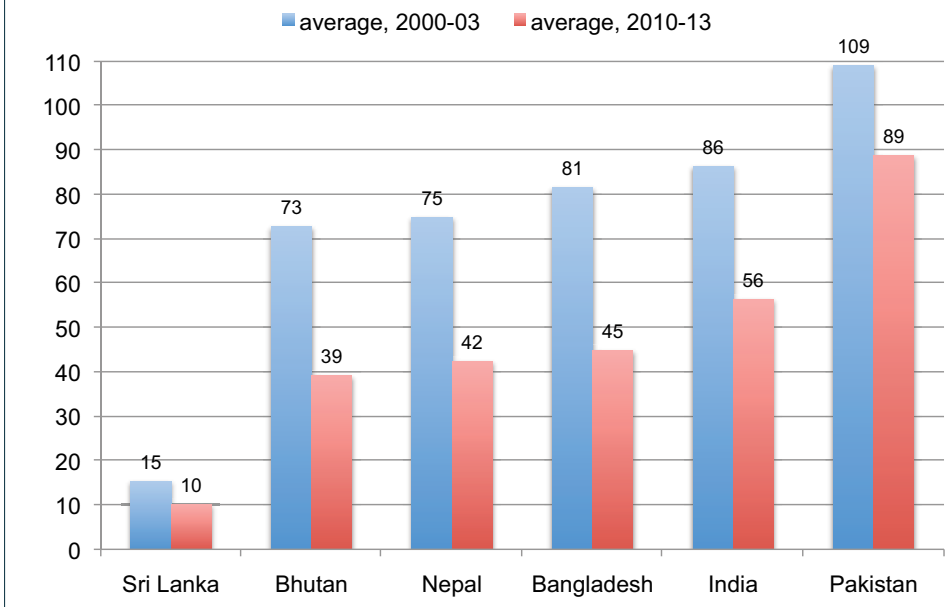
- **Health sector "inputs":** national per capita ratios of professional health care providers (nurses and doctors) and hospital beds, plus public health spending as share of GDP (a widely used crude proxy for national government commitment to financing programs that, in turn, are potentially relevant to child mortality rates);
- **Public health institutions:** national level performance of institutions – run by some combination of government, NGOs, private firms, and religious groups – that, directly or indirectly, impact five public health goals (access to safe water, access to sanitary toilet facilities, total fertility rate, child immunization, and access to mosquito nets in malaria-prone countries);
- **Social determinants of health:** female literacy, percent living below $1.25/day and per capita GDP;
- **Perceived effectiveness of national governments:** the perceptions by survey respondents as to the effectiveness of their respective governments in delivering services. The measure used, "government effectiveness", is one of six dimensions employed by the World Bank (2014b) in constructing the Worldwide Governance Indicators (WGI).

Our emphasis is on the performance of institutions.[2] The hardest to measure of the institutional factors we include is a measure of citizens' perceptions of the general effectiveness of their respective national governments in delivering services. The WGI define government effectiveness as "perceptions of the quality of public services, the quality of the civil service and the degree of its independence from political pressures, the quality of policy formulation and implementation, and the credibility of the government's commitment

1 The sample includes all countries with available data, having an average per capita GDP below a threshold of $5300 per capita GDP during the first four years of the millennium (2000-03). The World Bank defines various categories of countries based on per capita income. The $5,300 cut-off is the average per capita GDP among all countries over the years 2000-03 that it designates as "medium income".

2 In addressing the poor record of South Asian child health outcomes in the 1990s, Osmani (1997) raised three distinct perspectives. Our organization of relevant factors into four categories is a somewhat similar categorization. Drèze and Sen (2013, 51-53) assess India's social policy performance against 15 low-income countries outside Sub-Saharan Africa. Our list of factors overlaps theirs. The factors they measure include per capita GDP, life expectancy at birth, infant and under-five mortality rate, total fertility rate, access to improved sanitation, mean years of schooling, male and female adult literacy rate, undernourishment among under-five children and child immunization rate.

Figure 1: Under-Five Mortality Rate per 1000 Live Births, South Asian Countries, 2000-03 and 2010-13



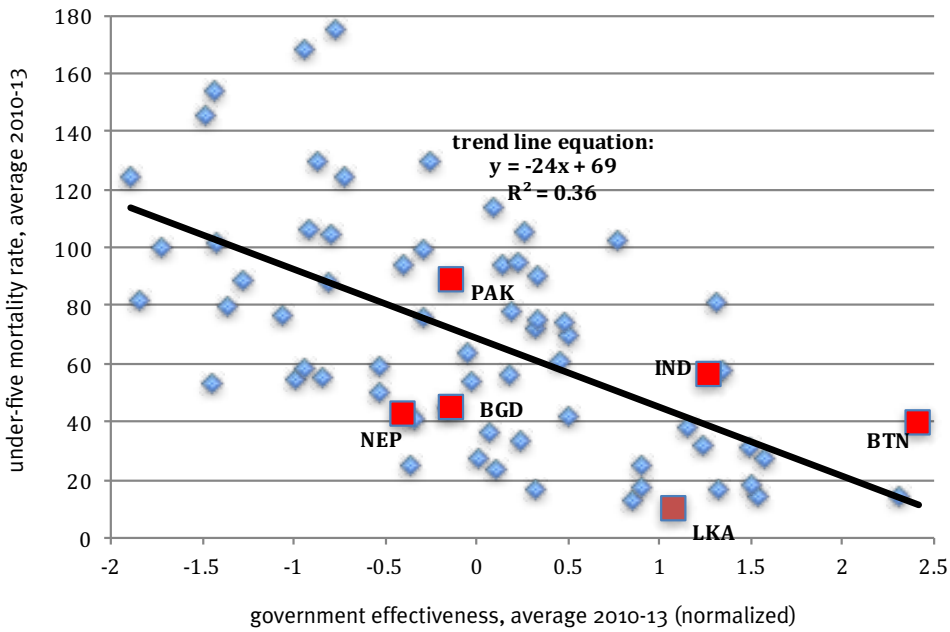
to such policies" (Kaufmann et al. 2010).[3] The WGI summarize a large number of surveys that in turn assess perceptions by respondents of the relative quality of the governance in their own and in other countries. The distributions of WGI country scores for each year and each dimension are standard normal. A country's score on any dimension is an estimate of its governance quality relative to the world average, which is set at zero. This normalization procedure implies no change from year-to-year in average global quality of governance.

Child mortality is a tragedy. Two-thirds of under-five deaths are estimated to result from weak infectious disease control (pneumonia, diarrhea and malaria being the three most prevalent of these diseases). As of 2012, global under-five deaths were estimated at 6.6 million, with nearly half in Sub-Saharan Africa and nearly a third in South Asia (UN, 2014, 25).

The UN's MDG campaign, launched in 2000, was intended to realize a set of ambitious social policy goals, the reduction of child mortality prominent among them. The fourth MDG specifically aims to lower the 2015 global

3 The other five dimensions are voice and accountability (a measure of freedom of speech and government accountability), political stability, rule of law, regulatory quality, and control of corruption.

Figure 2: Under-Five Mortality Rate by Government Effectiveness, Low-Income Countries 2010-13 (n = 69)



under-five mortality rate by two-thirds relative to the 1990 rate. The global average rate of child mortality in 1990 was 90 deaths per 1000 live births. By 2013 it was nearly half that: an impressive improvement. The rate of decline in the mortality rate accelerated in the early years of the new millennium. Unfortunately, the rate of decline has slowed since 2007, and the MDG child mortality goal will not be met by 2015.

Figure 1 displays the average 2000-03 and 2010-13 under-five mortality rates for six South Asian countries. Sri Lanka is the outstanding performer. Not only does it enjoy the lowest mortality rates among South Asian countries in both intervals, Sri Lanka enjoys the lowest rates among all 77 countries in both decades. If we rank the 77 countries by under-five mortality rate this decade, Bhutan, Nepal, Bangladesh and India all fall in the second quarter. Pakistan falls in the third quarter.

Figure 2 is a scatterplot of average 2010-13 under-five mortality and average 2010-13 government effectiveness scores among 69 low-income countries (those with complete observations on all factors).[4] The implication of the trend line is that a one standard deviation

4 Among eight of the 77 countries, missing data prevent their inclusion in the regression analysis and in construction of the figures. Average effectiveness scores for the 69 countries have been transformed into standard normal format.

improvement in government effectiveness is associated with a (per 1,000 live births) reduction of 24 in the national under-five mortality rate. While there is a negative relationship, the data are not tightly concentrated along the trend line. Among the six South Asian countries, three (Nepal, Bangladesh and Sri Lanka) perform better than predicted based on the trend line; three (Pakistan, India and Bhutan) perform worse. Obviously, factors other than general governance effectiveness must be part of any explanation.

In our regression analysis we included the factors introduced above. Even after inclusion of these factors, general government effectiveness remains an important statistically significant factor in the explanation of child mortality. Not all analysts agree. A relevant exception is Quibria (2014) who argues that an emphasis on governance indicators exaggerates the importance of the national government. He cites Bangladesh as a relevant example. Its WGI indicators are, for all dimensions other than voice/accountability, below the average for countries in our sample. Despite this, he notes, Bangladesh scores better than many low-income countries on public health outcomes, including under-five mortality. Quibria argues Bangladesh has developed civil society substitutes (NGOs and private firms) to deliver services that, in better-governed countries, are reliably supplied by the state or by closely regulated private firms. We agree with this explanation, but Bangladesh is an outlier among low-income countries in having very large effective NGOs that, in the health sector in particular, substitute for low quality of state governance (Lewis 2011; Smillie 2009). In general, bypassing the state is not a feasible strategy for improving health outcomes in low-income countries (Ramesh et al. 2015).

To summarize the results of the regression analysis (not shown in this article), five variables are closely associated with lower national child mortality *levels*: government effectiveness, child immunization rate, an index of access to safe water and sanitary toilets, total fertility rate, and female literacy.[5] Variations in other variables are less closely associated with child mortality. This second set includes public health spending as share of GDP, an index of health sector "inputs" (per capita ratios of nurses, doctors and hospital beds), access to mosquito nets, and per capita GDP. Collectively, the variables account for approximately three quarters of the cross-national variation in child mortality levels.

In attempting to explain *changes* in national child mortality between the first interval (2000-03) and the second (2010-13), only three variables are statistically significant in difference form: change in immunization rate, change in use of mosquito nets (largely in Sub-Saharan Africa), and change in percentage living below $1.25/day. These results suggest that small "on the ground" improvements in governance quality, for example the wider distribution of mosquito nets, can be important.

In difference form, government effectiveness as measured is not significant. However, average levels of national governance over the decade affect the change in national mortality rates in a statistically significant and intuitively understandable manner. All else equal, those countries experiencing below-average government effectiveness over the decade

5 The regression results are available from the authors by request.

achieved less in terms of mortality reduction. Furthermore, a "unit" increase in effectiveness contributed more among countries with below-average governance than among countries with governance above the sample average.

Characteristics of Top-Quarter Countries

The *change* regressions suggest the importance of average government effectiveness and improvements since 2000 in three variables. Improvements in immunization and in use of mosquito nets do not require what we would normally consider "high level" government effectiveness. In contrast, the level regressions imply that low child mortality is associated with superior outcomes on a second set of factors, many of which are outcomes of administratively complex institutions – for example, success of schools in achieving female literacy, success of infrastructure agencies responsible for sanitary toilet facilities and safe drinking water, and of a range of government and civil society organizations seeking to lower total fertility.

The difference between the two sets of factors is an example of the distinction that the Nobel-winning economist Douglass North (1990) drew between "institutions" and "organizations". Institutions embody the formal and informal "rules of the game" and constrain decisions; organizations maximize subject to the rules established by relevant institutions.[6] When a government contracts with a NGO or firm to distribute mosquito nets, the successful organization presumably maximizes its net benefit while doing so. It is relatively easy to monitor performance, and audit for corruption. This is not the case with school systems or water and sanitation systems. These are complex institutions that embody many formal rules and informal conventions, which are politically hard to change and often seriously inefficient in terms of realizing stated goals. Drèze and Sen (2013) discuss complex inefficient patterns of rent-seeking prevalent in India's contemporary education system. Plummer and Cross (2006, 10) discuss analogous problems with respect to water and sanitation systems in Sub-Saharan Africa:

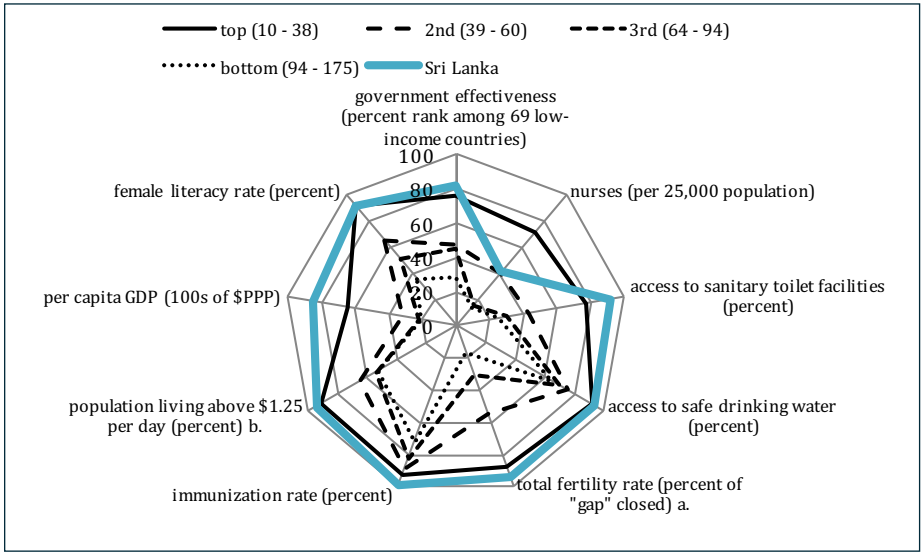
> *[Water and sanitation] sector corruption involves, to some degree, a vast range of stakeholders. The list of actors includes international actors (both donor representatives and private companies and multinationals), national and local construction companies, consultancy firms and suppliers, large and small-scale operators, a range of middlemen, consumers and [civil society organizations] as well as national and subnational politicians, and all grades of civil servants and utility staff. Corrupt activities between these partners occur at a range of institutional levels, with different stakeholders often involved in one or more types of corruption.*

In constructing Figure 3 we rank the 69 countries in terms of under-five mortality. All panels of the figure show the average value of the selected variables within each quarter, the quarters defined by the under-five mortality quartiles. (We rescale some variables to facilitate comparison.) In each panel we

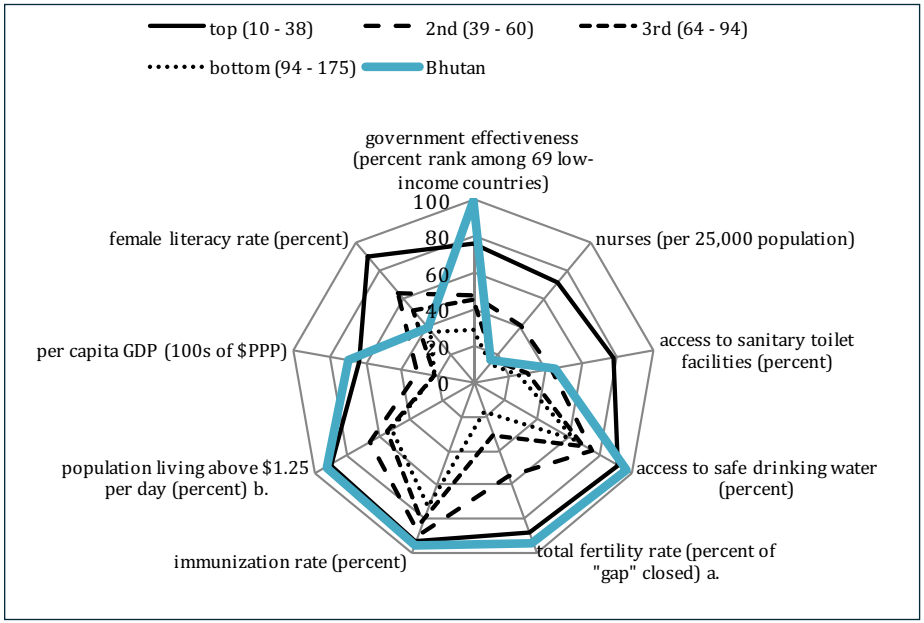
6 Avellaneda (2006) offers an extensive review in a developing country context of neo-institutional analysis inspired by North.

Figures 3: Profiles for South Asian Countries Relative to Quarter-specific Averages of Selected Variables among Low-Income Countries, 2010-13 (quarters defined for 69 low-income countries ranked by under-five mortality rate)

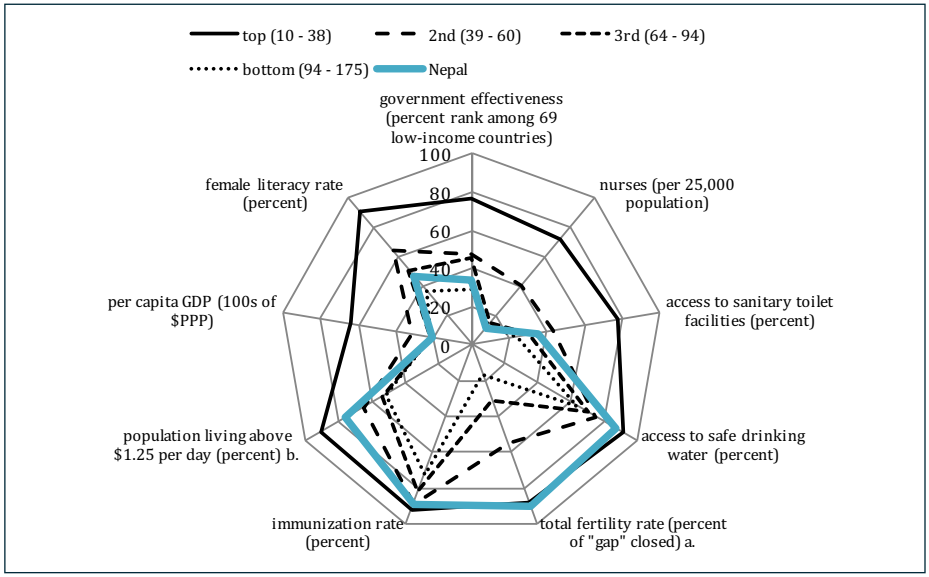
3a: Profile for Sri Lanka



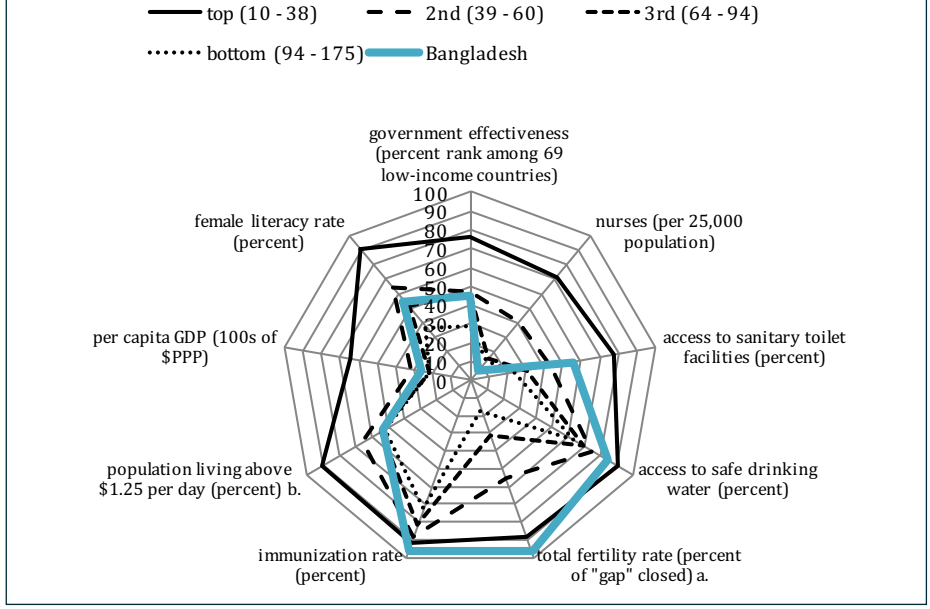
3b: Profile for Bhutan



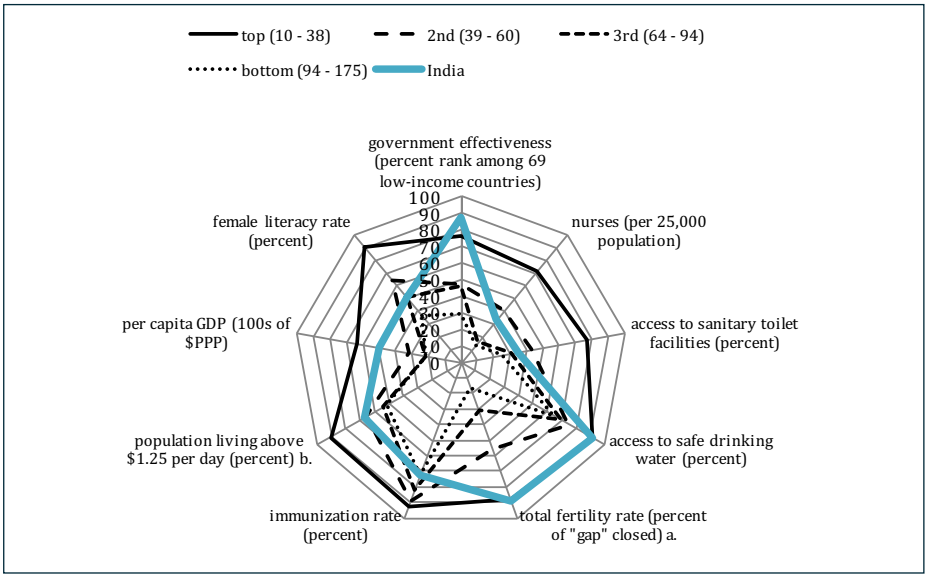
3c: Profile for Nepal



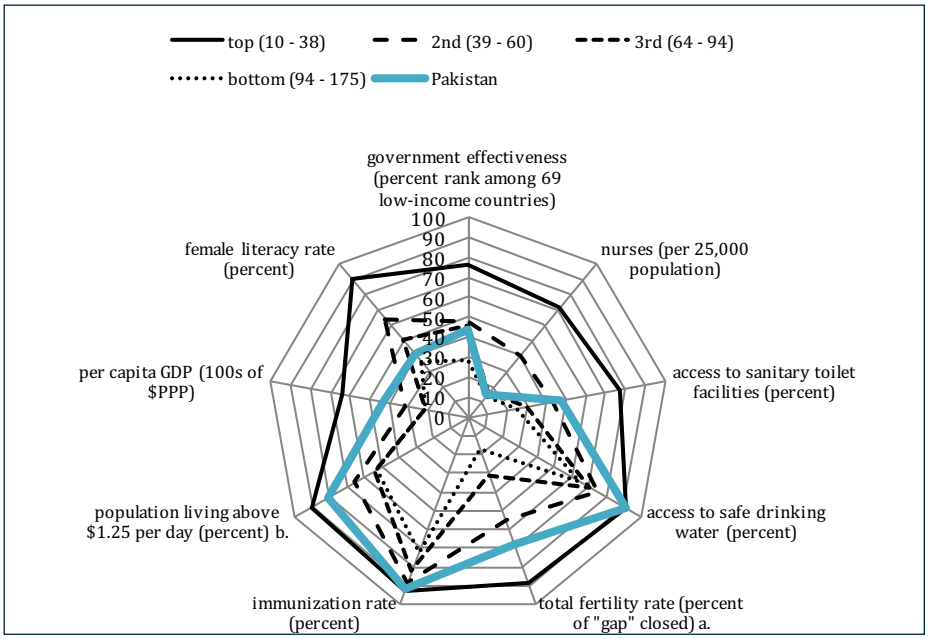
3d: Profile for Bangladesh



3e: Profile for India



3f: Profile for Pakistan



Notes to Figure 3

a. The "gap closed" is defined relative to the difference between replacement-level total fertility rate (TFR) of 2.1 children per woman and 6.06, the highest quarter-specific average TFR among the sample in 2000-2003. For example, the top-quarter TFR in 2010-13 averaged 2.58, equivalent to 87 percent (100*[2.58 – 6.06]/[2.1 – 6.06] = 87).

b. N=50. However, intervals are defined by quartiles of the 69-country sample.

c. Some variables have been rescaled to facilitate comparison.

d. The range of under-five mortality per 1000 live births (2010-13) in each quarter is provided in parentheses in the legend.

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superimpose the profile of one of the six South Asian countries.

The first dimension of the cobweb shows quarter-specific averages for government effectiveness scores. As expected, the ranking is consistent with the ranking of quarter-specific average mortality rates. Proceeding clockwise, the next dimension shows quarter-specific averages for per capita nurses, a proxy for the supply of professional health care providers and hospital beds.[7] While variation in the health inputs index is not significant in any regression, health systems obviously require health professionals. Next are measures of performance of four public health institutions, followed by two measures of economic well-being and, finally, female literacy.

As evidence that immunization is a public health institution less requiring of high-level governance quality than the other public health measures and nurse training, note that it is the dimension displaying the highest average performance among the measures of health institutions. It also displays the minimum range between average performance in the top and bottom quarters.

An important point illustrated by Figure 3 is that the top quarter countries, on average, outperform the comparable averages for the three other quarters on *all* variables illustrated. There are no inversions. The same dominance on all variables is evident in comparing the second relative to the third and fourth quarters, and the third against the fourth. (Albeit, the differences along some dimensions between second and third, or third and fourth, quarter outcomes are small.) While factors requiring little in the way of high-level governance are important in understanding *changes* in mortality rates over the decade, achieving top-quarter mortality *levels* seems to require above-average outcomes among the factors that do require a reasonable quality of high-level governance.

The first panel of Figure 3 concerns Sri Lanka. The allocation of sufficient resources and attention to implementing successful social policy are not automatic. Sri Lanka's profile

7 Of the three components (per capita ratios of doctors, nurses and hospital beds) in the health input index, the most important in comparison of national health systems is probably the ratio of nurses (Berland 2014).

reveals a country whose performance on all variables, except nurse-to-population ratio, is superior to the average among top-quarter countries. On the dimension of female literacy, no other South Asian country reaches the average for even second-quarter countries. Admittedly, on an intergenerational basis the relation between superior health and education outcomes on the one hand, and per capita GDP on the other, is reciprocal. No doubt, Sri Lanka's relatively high per capita GDP contributed to its superior heath and education outcomes, but these outcomes in turn are an important reason for the country's relative affluence.[8]

Bhutan performs above the top-quarter averages on six of nine variables, Nepal and India on four. India's overall government effectiveness score is high but there is a large variation across states, which the WGI do not adequately reflect. Bangladesh performs at or near top-quarter averages for three variables (access to safe drinking water, control of fertility, and immunization). Worth emphasizing, Bangladesh has by far the highest percentage among South Asian countries of its population living below $1.25/day. Child mortality results for Pakistan are disappointing. It performs at or near top-quarter levels on three variables (access to safe drinking water, percent above $1.25/day and immunization).

Conclusion

In the last decade, there has been some backlash against invoking governance quality in addressing development outcomes (Sachs 2005; Oman and Arndt 2010; Quibria 2014). Our findings, however, are consistent with the idea that the overall quality of government delivery of services does indeed matter.

In conclusion, we emphasize an argument made by many others.[9] Achieving good social policy outcomes is important not only for humanitarian reasons. A sustained political commitment to realizing good education and health services is among the best means whereby governing elites can commit to sharing the benefits of economic growth, and thereby obtain popular support for economically efficient public policies.

8 During the interval 2000-03 Sri Lanka's per capita GDP averaged $5100, during the interval 2010-13, $8500. The $3400 increase over the decade is the sixth largest among the 69-country sample.

9 As example, we note that Acemoglu (2008) makes this argument in the context of a set of essays defining the concept governance.

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Facebook Marketing

Creating Opportunities for Women Entrepreneurs in Bangladesh

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ABSTRACT: *Facebook marketing is the most popular method for online marketing today. You will hardly find any business now without a Facebook presence. The main advantage of Facebook marketing is its vast audience. According to Facebook, there are currently over one billion daily active users on average. The number of businesses using Facebook is growing rapidly around the world, even in our country. From large conglomerates to small businesses, most are on Facebook. Both large and small companies are promoting their products on Facebook. In Bangladesh, like most of the world, Facebook marketing has created opportunities for women entrepreneurs who can now sell different products from their home. Many fashion boutiques have flourished over the last few years solely depending on Facebook for their marketing efforts. Even though the number of Facebook "likes" seems to be related to the popularity of the brand, research shows that the key performance indicator is the Facebook Engagement Factor (F.E.F), i.e., the number of people interacting with the page. This research paper contains survey results and in-depth analysis of 50 fashion boutiques in Bangladesh that use Facebook for marketing their products, the majority of which are run by women. They use paid advertisement, word of mouth, and frequent posts as tools to promote their page. The Facebook Engagement Factor, not the number of likes, is the determinant of how well the page is doing. Small business owners who market their products through Facebook pages thus have to concentrate more on increasing F.E.F than the number of likes of their page in order to be successful.*

KEY WORDS: *Facebook Marketing, Women Entrepreneurs in Bangladesh, Facebook Engagement Factor.*

Introduction

MARK ZUCKERBERG, THE CEO and founder of Facebook, said, "When everyone has a voice and power, the system works very well." Facebook has become an addiction. It has introduced a new viral culture. When a person meets another, they now say "Are you on Facebook?" rather than "Can I have your number?" According to Facebook statistics, there are currently over one billion daily active users on average.

Facebook was founded by Mark Zuckerberg and his college roommates in 2004. It has now become a very powerful and important communication tool. Facebook is no longer limited only to social networking; it has become a platform for all kinds of businesses. As Mark Zuckerberg said "If I had to guess, social commerce is the next area to really blow up." It is estimated that 90 per cent of all purchases are subject to social influence, and by 2015 the social commerce market is expected to be worth $30 billion (Smith 2015).

The scenario in our country is no different. According to Internet World Stat there are 28 million Facebook users in Bangladesh (as of November 2015). All the top brands of Bangladesh, such as Grameenphone, Robi Axiata, Airtel Buzz, Aarong, Ponds, Unilever, Qubee and others, are on Facebook. Apart from the established brands, many small businesses are on Facebook.

Social media is affecting our lifestyles. Facebook can be a powerful tool for promoting any cause. We can see today that there has been a steep increase in the number of bicycle riders in Dhaka. That is in part because many different pages have started promoting the use of bicycles as a healthier transportation system and an alternative to avoid traffic jams. Social media has also changed the way we shop. The rise in the number of online businesses indicates that our buying behaviour has also changed. We have now become habituated with online shopping. Avoiding all traffic, pollution, and hot weather, people now find it convenient to shop sitting at home.

In Bangladesh, there are, at present, numerous small businesses on Facebook, and many of these businesses are fashion boutiques (Zabeen et. al. 2013). This research paper will give an insight into these businesses.

Literature Review

Digital marketers are shocked by the fact that Facebook now has more users per month than Google (Ingram 2015). Marketers also now realize that apart from social networking, Facebook can offer unique marketing opportunities for businesses. Facebook offers a free marketing tool that almost any businesses can use. A Facebook page allows a businesses to introduce themselves by telling what they do. Business owners share images, posts, offerings, etc. to keep viewers engaged. This is a great platform to personally interact with customers. Any news regarding your business, such as new products or services, can be posted here so that prospective customers can view it. Facebook pages are a great way to achieve quality leads for products or services. Some Facebook pages have an e-commerce component linking shoppers directly to make purchases, but users can also share what they've purchased, and "like" products at the same time (Stampoulaki 2012).

Some businesses used to even sell directly through Facebook. The first Facebook transaction can be dated back to February 2007, when Facebook's Virtual Gift Store was opened. After two years, the virtual store 1-800-Flowers made its first Facebook transaction for $34 (Stampoulaki 2012). However, there was not much prospect in selling directly through Facebook. Most companies instead use Facebook as one of their major marketing tools. The top three brands of the world Coca-Cola, Starbucks, and Disney all actively maintain their Facebook pages for promoting their brand.

Some interesting statistics regarding Facebook (Smith 2016, Cooper 2013):

- There are currently 1.591 billion monthly active Facebook users.
- Canada has the highest number of active Facebook users per capita in the world.
- On average, people spend 20 minutes on Facebook daily.
- 91 per cent of Facebook users are millennials (15 to 34 years old).
- 300 petabytes of user data are stored on Facebook.
- On average, there are 934 million mobile daily active Facebook users.
- The highest Facebook traffic occurs between 1 pm and 3 pm.
- Engagement rates on Thursdays and Fridays are 18 per cent higher.
- 35% of Facebook users have liked a page in order to participate in contests.

Consumers' buying behaviour has changed. Consumers now trust recommendations three times more than online ads (Knight 2011). According to Nielsen's 2015 report on Global Trust in Advertising, trust in ads on social networks is 46 per cent. Facebook marketing lets shoppers view what friends "like" on Facebook and with the use of social intelligence, make better shopping decisions. On the other hand, consumer brands promote their products and services on Facebook for brand insight (trial), brand loyalty (repurchase), brand advocacy (word of mouth), brand experience, and return on investment (low advertisement cost). Shopping spreads like a virus on Facebook; anyone who provides good content will benefit from its viral nature. Researchers say there are two reasons why businesses need Facebook: engagement and data. But sales are not equal to data and engagement (Marsden 2011).

The experience of Facebook marketing relates to brand engagement, consumer support, and information sharing. Diesel's DieselCam was one such example. DieselCam was a mirror in a fitting-room that was connected to Facebook. This let shoppers share images of clothing they were trying and get feedback from their Facebook friends on which clothing looked good on them (Marsden 2011). Heinz's 'Get Well Soup' campaign is another example of using Facebook marketing to promote a brand. Heinz' idea was simple; it let consumers buy a can of soup for a friend who was ill and asked for it to be sent along with an individualized 'Get Well Soon' message. The campaign offered something personal that created a strong customer engagement. Sally Meekins, the Marketing Executive of Heinz at that time said, "It wasn't just the offer that people were engaging with, it was the idea

and what it says about the brand by bringing people closer" (Soen 2015).

Research shows that small businesses are the real innovators of Facebook marketing. A survey conducted among 1,600 businesses, most of them small and medium enterprises (SMEs), revealed that 17.7 per cent of their company's revenue for the year 2012 came from Facebook marketing campaigns (Hershkovitz 2013). Generally speaking, it is a common understanding that social media is not good for selling directly; however, social media has a major role in companies' branding. Owners of many small businesses believe that the fact that large audience can be reached through Facebook promotions, events, video and photo sharing has played an important role in building rapport with prospective customers (Ouimet 2012).

Millennial Shoppers

Changes in buying behaviour are in large part due to the rise of the millennial. Aged between 18 and 30, millennials don't give much importance to holding a product in their hands in deciding whether to buy it; instead, they focus on the use and easy acquisition of a product. There has been a decrease in engagement with malls and physical media. For example, in 2013 there was a drop in CD sales by 13 per cent, and an increase in digital formats by 9.1 per cent. The same condition is observed for mail; people prefer electronic bill payments. Millennials watch five hours and 39 minutes of online video every day, instead of watching TV; they prefer reading magazines on laptop or tablet (Bonini 2013).

A recent study by e-tailing group and Power Review indicates that 57 per cent of customers take the help of search engines to find information related to entertainment, restaurants, nightlife, etc. (Business Wire 2010).

Research by Service Management Group and The Boston Consulting Group, Barkley revealed the following interesting insights about millennials:

- Millennials see the Internet as a broadcasting platform for sharing their experiences and thought. They are very comfortable using social media and technology.
- Millennial are extremely engaged in activities like rating services and products (60 per cent of millennials compared to 46 per cent of non-millennials) and uploading images, blogs and videos on the Internet (60 per cent of millennials compared to 29 per cent of non-millennials).
- Millennials prefer ease, speed, convenience, and efficiency in their transactions. For example, they shop more often, almost double, at convenience stores for groceries compared to non-millennials.
- Millennials depend more on peer recommendations than expert recommendations.
- More millennials than non-millennials admitted reading user reviews using a mobile device and researching products while shopping (50 per cent of millennials compared to 21 per cent of non-millennials).
- Millennials are much more likely than non-millennials to research on brands on social networks (53 per cent of millennials compared to 37 per cent of non-millennials).

- In considering purchases, millennials tend to prefer brands having mobile websites and Facebook pages (33 per cent of millennials compared to 17 per cent of non-millennials).
- Millennials admit their life feels worthwhile when they are on social media like Facebook (47 per cent of millennials compared to 28 per cent of non-millennials).

Millennials are thoughtful and intelligent customers, according to marketing experts. They are always looking for good bargains. In fact, their behaviour is forcing companies to alter their way of doing business. Phillips, a professor of marketing at the University of Notre Dame Mendoza College of Business, said, "While others may take time to research the best deal on major purchases like a TV, this generation does it for lipstick." A study conducted in 2010 by Edelman and its research arm StrategyOne indicates that 42 per cent of millennials look at at least four sources before making their final buying decision (Dexheimer 2012).

Women Entrepreneurs

A revolution is taking shape among women nowadays. Women today are leaving the workforce in multitudes in favour of being at home; not for becoming homemakers—but for being entrepreneurs. Women will create over half of the 9.72 million new small business jobs expected to be created by 2018 and more and more are doing this from home offices across the country (VanderBrug 2013). Studies by the Small Business Administration show that in the last 10 years women-owned businesses increased by almost 90 per cent. Internet marketing is a major part of business. Many stay at home mothers who were once in the corporate world are the biggest advocates of business ownership because they see that it as the best way to create a balance between their family needs and the ability to do something creative. The majority of women entrepreneurs view the Internet as their most important business tool (Ray, n.d).

There are more than 28 million active Facebook users in Bangladesh (Internet World Stat 2015). Facebook marketing is growing fast in our country. Some popular Bangladeshi e-commerce websites are Bikroy.com, Hutbazar.com, Akhoni.com, Technobd.com, Cellbazaar.com, ClickBD.com and Ekhanei.com. Facebook marketing has made a strong foothold in businesses in this country. Like the rest of the world, women entrepreneurs in Bangladesh are also on the rise.

Survey Objectives

BROAD OBJECTIVE: To find out whether Facebook marketing has created opportunities for women entrepreneurs in Bangladesh.

SPECIFIC OBJECTIVES:

a. To find out whether women are mostly the owners of these small businesses.
b. To find out the various motivational factors behind doing these businesses.
c. To find out the various promotional activities done on these Facebook pages.
d. To find out whether the number of "likes" is the only key performance indicator for business success.

Methodology

RESEARCH DESIGN: Exploratory research was conducted. Secondary data analysis and online survey were used for this research.

TARGET POPULATION: The target population for this research is fashion boutiques that use Facebook marketing.

SAMPLING FRAME: Owners of these online fashion boutiques were chosen for survey.

SAMPLE DESIGN AND SAMPLE SIZE: Non-probability sampling (judgment sampling) was used. Online fashion boutiques with more than 300 likes were chosen. Fifty such stores were chosen as sample.

DATA COLLECTION PROCEDURE: Both primary and secondary data collection procedures were used. Primary data was collected through surveys. Sources of secondary data were websites of the stores, books and periodicals, media sources, and online articles, essays and journals. The owners of these small businesses were asked to fill in a questionnaire.

DATA ANALYSIS: Content analysis procedure was used to analyze the survey data. The attribute that has the greater number of respondents is said to be true.

LIMITATIONS: All fashion-boutiques using Facebook marketing in Bangladesh could not be covered due to lack of information. No database yet exists on such businesses. The validity of some answers, e.g., income per month, are dubious.

FINDINGS

The findings are based on the questionnaires filled in by the owners of 50 fashion boutiques that use Facebook marketing and by analyzing the activities of these pages.

Owner's personal attributes

Attribute	Response
Gender of owners	Female: 96% Male: 4%
Age group of owners	16–20: 6% 21–30: 38% >30: 56%
Owner's educational qualification	SSC & HSC: 10% Bachelors: 52% Masters: 38%
Owner's profession	Service holder: 16% Student: 28% Home maker: 56%

Owner's Business Attributes

Attribute	Response
Year of opening business	2010: 2% 2011: 8% 2012: 14% 2013: 66% 2014: 10%
Reason behind doing such business	Extra income: 44% Unable to work outside for maintaining family: 56%
Means of doing business	Import: 42% Buy from wholesaler: 28% Self-design: 30%
Number of "likes"	0–1,000 likes: 30% 1,000–5,000 likes: 30% 5,000–20,000 likes: 16% 20,000–50,000 likes: 18% >50,000 likes: 6%
Engagement ratio	<1: 22% >1 &<5: 64% >5: 14%
Promotional method used to increase fan base	Only advertise on Facebook: 56% Run contest and advertise: 10% Word of mouth: 26% Frequent posts: 26% Email marketing: 0% Distribution of leaflets: 0%
Means of advertising on Facebook	Contact Facebook directly: 100% Use local agency: 0%
Kind of posts given	Only new products: 84% New products and other interesting posts: 16%
Reason why customers buy	Cheaper than stores: 10% Quality products: 70% Ease of shopping: 20%
Have physical store	Yes: 54% No: 46%
Status of business	Loss: 0% Struggling: 0% Profit: 100%
Average income per month	<10,000: 0% 10,000–30,000: 44% 30,000–50,000: 0% >50,000: 56%

ANALYSIS

The survey found that the majority of these business owners are female. Not only in Bangladesh, globally the number of female entrepreneurs has increased. Statistically, approximately 37% of enterprises globally represent women-owned entities – a market worthy of attention by businesses and policy makers alike. Despite the equal-rights movement in favour of equality for women, Bangladesh still remains a male-dominated society. Women in Bangladesh still face the obstacle of working outside, especially after they have children, even though they are highly educated. This is one of the main reasons behind the increase in the number of women entrepreneurs.

As convenient payment gateway systems are still not underway in Bangladesh, many businesses find it hard to use the Facebook's advertisement and other features that require paying through international credit cards. New businesses are flourishing in Bangladesh to solve this problem. DevsTeam and Trump

Marketing Solutions are two such firms that support online marketing, including Facebook advertisements. Findings of our survey show that pages that depend on Facebook advertisement for promoting their business contact Facebook directly. This is because either people are not yet aware that local online marketing firms now exist or because they want to manage these tasks themselves.

Facebook is now generating revenue from its business user base, which is bad news for the small businesses. New York Times columnist Nick Bilton describes how he had a Facebook subscriber list of 25,000 and would receive 535 "likes" after posting a link to one of his columns. His subscriber list had since grown to 400,000, but he now averaged only 30 "likes" per post. He did an experiment and found that when he paid $7 to promote a post on Facebook, he had a 1,000 per cent increase in interaction.

According to the survey findings, the majority of the pages are depending on Facebook ads to increase their fan base. There are other effective methods to increase a fan base, such as making interesting posts or run contests, but this is only a minority of the cases. Most of these fashion boutiques are importing Pakistani lawns and Indian dresses. There is huge demand for these products in our country right now. Whenever businesses post pictures of new clothing items, people view that clothing and possibly click "like." This might be one of the reasons they don't have to give other interesting posts on their page.

Running contests has been a trend for large companies. Ponds' selfie photo contest and Qubee's movie contest for the Valentine's season were successful in creating "buzz" in the market. Imagine you bought a Ponds cream or installed Qubee in your computer. Do you feel like going to their Facebook page and clicking "like"? But if you know that by clicking "like" you could win a chance to have romantic dinner at a five-star hotel, or win a movie ticket, then you perhaps would click the "like" button. Contests can be a promising area that small businesses might focus on.

Once a business page is created, the owner needs to get users to visit it and, hopefully, to "like" it. If people "like" the page, posts will then appear on that user's Facebook newsfeed. Over time this will allow the business, according to Facebook, to start "building loyalty and creating opportunities to generate sales."

Our research findings show that most of these Facebook-based fashion boutiques started operating in 2013. The number of followers (fan base) of some of these stores are huge, some even exceeding 50,000 likes in just one year. Gaining this volume of fans in such a short time isn't possible without using Facebook's paid ad and "promote" options. But whether these "likes" represent actual potential consumers is sometimes questionable.

False Likes

Business Insider reported that Raj KapurBrar, the owner of a number of fashion magazines, had his Facebook fan page overcrowded with fake likes from false accounts. There is no way a user can differentiate between fake fans and the real ones. This man's $600,000 Facebook disaster is a warning for all small businesses (Edwards 2014).

Then there are fake clicks from click companies, which is an illegitimate business within

social media marketing. Mostly available from Asia, these click companies deceive by providing huge numbers of cheap clicks that would not occur otherwise (Edwards 2014). This emphasis on likes is considerable with customers. Research suggests that 27 per cent of consumers will have a look at the likes and 90 per cent of them will look at the online reviews before deciding to buy a product (Rudolf 2015). This shows that click companies could easily misdirect consumers.

According to an article published in the newspaper ProthomAlo, some people click "like" when they really like the brand, and some do it to show off. Kevin Lewis and fellow researchers at San Diego University, California, found that "like" doesn't reflect actual liking. Mining information from a revolution page "Save Darfur" up to January 2010 they found there were 1.2 million "likes.'" But the fund earned was only 8 cents. The amount collected was much more through direct emailing. Only in 2008, they were able to earn $1 million through direct emailing. Another article from the same newspaper says that software called 'BOT' can be used to automatically generate "likes" on Facebook page. Whether these likes are really reflecting the customer's choice of brands is an outstanding question.

Customer Engagement – the Key Performance Indicator

One quick indicator for the health of a Facebook page is the "Talking About This" metric. This metric shows how engaged your audience is. According to the blog ReferralCandy, the number of "talking about" divided by the number of "likes" is a good indicator of the number of actively engaged users on your page. This is called the Facebook Engagement Factor.

Facebook Engagement Factor (F.E.F.)= (Number Talking About This / Number of Likes) x 100

Engagement is needed to convert your audience to action. Facebook engagement rates are measured in terms of interactions, for example comments, likes, and shares of your posts. According to Michael Leander, a marketing expert, engagement rate greater than 1% is considered good, 0.5 to 0.99% is considered average, and less than 0.5% is poor.

The top 10 stores, from my survey, with the highest Facebook Engagement Factor were:

- Parizaat Online Fashion Attire, F.E.F = 0.17; 21,131 likes
- Azwaa, F.E.F = 0.19; 58,321 likes
- ViVaciOus, F.E.F = 0.77; 66,385 likes
- Tress Fashion, F.E.F. = 0.25; 2023 likes
- Womanhood Fashion, Health and Beauty, F.E.F. = 0.15; 27,808 likes
- Okay Fashion, F.E.F. = 0.12; 40,067 likes
- Monsoon Online Shopper's Stop, F.E.F. = 6.75; 155,523 likes
- Panache Women's Wear, F.E.F. = 0.13; 65,155 likes
- Apsara's Style World, F.E.F. = 0.13; 16,486 likes
- Fashion Stitch, F.E.F. = 0.11, 9,001 likes
- Fashion Reveal, F.E.F. = 2.17; 670,301 likes

The figures above show there is no clear correlation between the number of Facebook likes and Facebook Engagement Factor. For those pages whose number of Facebook likes is high, but the engagement factor is low, it's time to reconsider strategies to improve page posts.

Recommendations

After analyzing the results of this research, we recommend the following:

1. Marketing through Facebook has become viral.
2. It is important for shop owners to study the different marketing strategies that can be used for their business.
3. It may be beneficial to assign some budget for advertisement and other promotions like coupons or contests.
4. Frequent and interesting posts keeping customers engaged.
5. Many people buy from these shops because of recommendations from friends. So updating the page on a regular basis with recent information is very important.
6. Having a sales website along with the Facebook page is required.
7. Number of "likes" does not tell the whole story in measuring the success of Facebook marketing. Numbers of engaging customers are the key to sustainable business operation through Facebook marketing. Therefore, the focus should be not just to increase the number of "likes," but to increase the number of engaged customers.

Annex

Questionnaire (you can provide multiple answers to a question, if needed):

- Which age group do you fall in? 16-20; 21-30; 30-40; 40+
- What's your educational background? Up to SSC and HSC; Bachelor's degree; Master's Degree; Other (please mention)
- What's your profession? Service holder; Business man/Woman; Student; Home maker; Other (please mention)
- What inspired you to do such business? Wanted it as an extra income generator besides my own profession; Just for fun; Unable to work outside home so doing something home-based; Other (please mention)s
- How do you get the products? Import; Buy from local wholesaler; Other (please mention)
- Which method do you use to increase your fan base? Advertising on Facebook; Email to friends; Distribute leaflets in your locality; Run Facebook contests; Word of mouth; Frequent post
- If you are advertising on Facebook, how do you do it? Contact Facebook directly; Use a local agency to do the work
- Do you have a physical store? Yes; No
- How do you describe your business? Loss; Struggling; Profitable
- What's your average income per month from the page? Tk. <10,000; Tk.10000-30000; Tk. 30000-50000; Tk. >50000

- Why do you think customers buy from you? Cheaper than stores; Quality products; Ease of shopping; Other (please mention)

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Assessment of the Integrated Urban Water Management Strategic Plan of Accra City

Using Aquacycle13 Model to Develop an Outline of the Strategic Directions for Dhaka City

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ABSTRACT: *Accra, the capital city of Ghana, is facing on major challenges in both water supply and sanitation. Urban sprawl has outpaced planning of infrastructure and public services by more than a decade due to rapid urbanization and a high population growth rate. As a result, providing water and sanitation services to all in a fast growing, largely unplanned city like Accra is a great challenge. In order to meet these challenges, the Integrated Urban Water Management (IUWM) is introduced and IUWM provides an outline for planning, designing, and managing urban water systems. Although, Accra and Dhaka city are geographically located in two different regions on the earth, but there are some similarities, which have been found between them. Similarly, many differences have also been observed. In addition, the IUWM strategic plans of Accra city have been assessed by the two different engineering tools in order to generate different scenarios before and after considering the strategic directions suggested by the SWITCH—Sustainable Water Improves Tomorrow's Cities' Health project. In this regard, Aquacycle13, a modern urban water balancing model has been used in this study where the developed scenarios have showed the future prediction on the basis of the different strategies that must be executed in future. Finally, this study makes an outline of IUWM strategic directions for the Dhaka city in Bangladesh, based on its future challenges and lesson learnt from the existing strategic plan of Accra, Ghana.*

KEYWORDS: ***sanitation, stormwater, water supply, wastewater, water management***

Introduction

About Accra City

Accra, Ghana's capital city, is the country's largest and fastest growing metropolis (Figure 1). In addition, people come to the city to trade goods (from November to April), so there is a fluctuation of its residential population (Adank et al., 2011). The city has been struggling to keep up with its high population growth (6-9% annually). The main challenge for Accra is to ensure water and sanitation services to all city dwellers. Most people do not have connection to the central water supply network and only a very small part of the city is connected to the central sewerage system. Accra is in a flood-prone area, partially caused by storm water and a poor drainage system (Adank et al., 2011). Although there have been several plans for the better management of urban water and sanitation services within the city, none of them so far have resolved the city's water management problems.

About Dhaka city

Dhaka, the capital city of Bangladesh, is experiencing similar water management problems to those in Accra (Figure 2). The Dhaka Water Supply and Sewerage Authority (DWASA) has estimated water demand as 150 litres per capita per day. But, presently one-third of city dwellers receive 40 l/p/d for their daily activities; the remaining two-thirds are not connected. Uddin and Baten (2011) found in their study that only 5 percent of the total population of Dhaka city receive more than 60 l/p/d; 43 percent of residents receive a basic requirement of 50 l/p/d. The rest of the city population (58 percent) suffer from water scarcity. Approximately 31 percent of Dhaka households have no access to piped

Figure 1: Location Map of Accra City

Source: https://www.googlemaps.com

Figure 2: Location Map of Dhaka City

Source: https://www.googlemaps.com

connection. They have to depend on NGOa or other sources, such as a standpipe. There is an obvious need of proper water management planning, to address Dhaka's future challenges without compromising the standard of living.

Assessment Tool and Modeling Concept

Engineering tools have been used to evaluate the strategic plans for the city of Accra. The Aquacycle modelling toolkit generates scenarios to measure the area's water balance and to model the study area in terms of its water resources and future options to meet the increasing demand. The scenario planning is used to forecast the future situation in terms of population, socio-economic growth and uncertainties.

About Aquacycle toolkit

Aquacycle is a daily urban water balance model, which simulates the total urban water cycle as an integrated whole and provides a tool for investigating water use efficiency and the use of locally generated storm-water and wastewater as a substitute for imported water. It has the capability of modelling a residential property through to an entire urban catchment. Land use in a cluster is separated into unit blocks (individual lots), road, and public open space. Road areas are assumed to be impervious to water and all public open space is assumed to be pervious. Unit blocks can be separated into roof, paved and pervious surfaces. Furthermore, the toolkit produces daily, monthly, and annual estimates of water demand, wastewater yield, storm-water yield, evaporation, imported water use, wastewater use and storm-water use. Finally, this model measures the impact of alternate water management strategies.

Input parameters for the model

Although the data available are not sufficient for a full analysis, we have attempted to understand the probable water balance situation in Accra. First, we use the daily recorded rainfall data of Accra city from 1970 to 2005. Annual variation in different years is quite high. Second, we use the 2010 population of Accra (about 3.5 million) in an area of 185 km2. The area has been divided into three different clusters on the basis of per capita income levels: a High Income Group (HIG), a Middle Income Group (MIG), and a Low Income Group (LIG) (World Bank, 2010). This division displays the expected positive correlation between water consumption and income levels (see Table 1). Per capita income is one of the important factors in water demand forecasting. Third, we assume an average household size of Accra of four per household as default value of the model. The existing treatment plant is designed to treat a total hydraulic flow of 16,080 m3/day (Adank et al., 2011). It will be necessary to undertake rainwater harvesting at the unit block level in order to meet the future water demand in Accra. Finally, the targeted amount of unaccounted for water (UFW) in the supply and distribution systems is presently very high, at 60%; the current strategic plans estimate it at only 25% (Adank et al., 2011).

Based on the parameters in Table 1, the average consumption per capita per day is 76 litres (120 * 0.10 + 90 * 0.32 + 60 * 0.58 = ≈76 litres). As the weighted average household size is 13[1], the water consumption is approximately 988 L/block (13 * 76 = 988).

As shown in Table 2, the total land area of Accra is about 185 km^2 including all occupancy types: residential, commercial, industrial, public open places and roads. Out of 185 km^2 total (Table 2), the area allocated among the three income groups are HIG 37 km^2 (20%), MIG 65 km^2 (35%) and LIG 83km^2 (45%). The table also shows the relative water allocation of each income group, in terms of garden, pavement and roof, as well as public space and roads. Table 3 shows more detailed area calculations under the different clusters.

In Table 3, the area of unit blocks is calculated by dividing the total area of the cluster by the number of blocks. And, the columns

Table 1: Water demand by different income groups in the Accra, Ghana

Income group	Per capita consumption (lpcd)	Average Household size	Percent of the population (%)
High income group (HIG)	120	8	10
Middle income group(MIG)	90	12	32
Low income group(LIG)	60	15	58

Source: Design parameters (Planning and Development Document for GWCL, Accra.) and (World Bank, 2010)

Table 2: Assumed area under each block (as it was not possible to collect original data)							
Group ID	Population	Area (km²)	Block			Public open space (%)	Road (%)
			Garden (%)	Pavement (%)	Roofs (%)		
HIG (10%)	350,000	37	40	15	25	10	20
MIG (32%)	1,120,000	65	25	10	20	05	20
LIG (58%)	2,030,000	83	15	05	15	05	15
Total	3,500,000	185					
Weighted average household size = (8*0.10+12*0.32+15*0.58) = 13.34, rounded at 13 persons							

Table 3: Calculated statistics for the model (according to the above proportion shown in Table 2)						
Cluster type	No of Block	Unit block (m²)	Garden + Pavement + Roof per Block (m²)	Public Open Space (m²)	Road(m²)	Total area (m²)
A	b	c = d + e + f	d	e	f	g = b x c
HIG	43,750	845	591.50	84.50	169.00	37,000,000
MIG	93,333	696	556.80	34.80	104.40	65,000,000
LIG	233,333	355	301.75	17.75	35.50	83,000,000
					Total = 185,000,000	
No. of Blocks = Population in the cluster/Household size in the cluster						

d, e and f have been calculated based on the percentages estimated for garden, pavement and roof in Table 2. For example, for the HIG cluster, the area for the garden, pavement and roof is 70% (20 +10 +40 = 70%) of the unit block area, which is 591.50 m2 (845 * 0.70 = 591.50 m²). Similarly, the calculated area for the public open space and roads are 10% (845 * 0.10 = 84.50 m²) and 20% (845 * 0.20 = 169 m2), respectively.

Results and Discussions

Output of the model

The table below illustrates the output of the Aquacycle model. In Table 4, the result shows the average of the annual water balance (1970 to 2005) for the catchment of Accra for both before and after considering the strategic measures suggested by the SWITCH project. Without considering strategic measures, the average requirement of imported water is found 693 mm². The storm-water runoff and the wastewater discharge are 629 mm and 428 mm, respectively. After considering the stra-

tegic measures (such as introducing multiple alternative sources of water) the amount of imported water has been significantly reduced, from 693 mm to 249 mm. In particular, the unit block rainwater tank with a capacity of 1.4 m^3 (size of the rainwater tank as optimised by the model) generated a good result that minimized the demand for reticulated water in the whole catchment.

The six existing wastewater treatment plants have a total capacity 16,080 m^3/day, which has been taken into consideration in the analysis, though few of the plants are currently functional. The current volume of unaccounted for water (UFW) is 60%. Therefore, the result of the model with the existing system is quite vulnerable. The existing system can only supply between 71% and 81% of the total demand.

Table 4: Average of the Annual Water Balance for the Catchment, 1970 to 2005

Component	Averages	
	Without considering strategic measures	After considering strategic measures
	(water depth in mm)	
Precipitation	745	745
Imported water	693	249
Stormwater inflow	0	0
Wastewater inflow	0	0
Evaporation	375	369
Stormwater run-off	629	420
Wastewater discharge	428	8
Change in storage	5	195
Transfer of water (+ve means net input)	0	0

With the strategic measures the volume of estimated UFW declines from 60% to 25% of the total. With these strategic measures, the water balance in the city is much better than previously and now it has more renewable water sources. For example, grey water is used for irrigation and gardening; treated wastewater and rainwater are stored and used for toilet flushing. Finally, these actions contribute to a reduced use of reticulated water in the city. If these strategic measures are implemented, Accra will be much more resilient and sustainable in terms of its water balance.

Evaluation of the different scenarios developed for Accra

To identify robust strategies to achieve the vision, scenarios of possible future trends have been developed, taking into account unpredictable external factors that have a great impact on outcomes.

Worst-Case Scenario (Table 5):

The worst-case scenario assumes a high rate of population growth of Accra, which in turn has a high level of influence on water demand and sewerage. The projected future population is more than four times its present level, causing water demand seven times the current demand.

In addition, climate change adversely affects outcomes. This scenario addresses the decline of river flows in the coming years.

Medium Case Scenario (Table 6):

In this scenario, the economic growth rate is good, due to oil exports. Public awareness is better than in the worst-case scenario, resulting in improved solutions for water-related problems. Moreover, other factors have a medium level of influence, and there are fewer adverse uncertainties compared to the worst-case scenarios. For example, there are no more power shortages and there is a lower rate of population growth.

Table 5: The influence level of factors in the worst-case scenario

Sl No	Factors	Level of Influence		
		High	Medium	Low
1	City population	+		
2	Economic growth			+
3	Effect of climate change	+		
4	Power/energy supply			+
5	Political commitment and interference			+
6	Public awareness and attitude			+

Table 6: The influence level of factors in the medium-case scenario

Sl No	Factors	Level of Influence		
		High	Medium	Low
1	City population		+	
2	Economic growth	+		
3	Effect of climate change		+	
4	Power/energy supply		+	
5	Political commitment and interference		+	
6	Public awareness and attitude	+		

Table 7: The influence level of factors in the best case scenario				
Sl No	Factors	Level of Influence		
		High	Medium	Low
1	City population			+
2	Economic growth	+		
3	Effect of climate change			+
4	Power/energy supply	+		
5	Political commitment and interference	+		
6	Public awareness and attitude	+		

Best-Case Scenario (Table 7):

The base case should be the medium-case scenario, which could be realized by adopting the strategic directions implicit in the SWITCH project. The best-case scenario is the ideal for realizing a sustainable and resilient future for the city, but it is the least likely. The worst-case scenario is not the most likely but the outcomes of such a scenario should be analysed. By highlighting the problems arising under the worst-case scenario, people may be more willing to undertake the initiatives implicit in the medium-case scenario

Strategic Directions for Dhaka City

In analysing the water management problem for Dhaka, there are strategic lessons to draw from our analysis of Accra. Managing water demand requires education, incentives, and enforceable regulations, and possibly water tariff adjustments designed to reduce consumption. Improving the Dhaka water management and sewerage sysem requires the following elements:

- Decreasing groundwater extraction gradually, by banning illegal private pumping wells;
- Expanding capacity of surface water treatment plants of the DWASA;
- Exploring alternative sources of water, e.g. rainwater storage and water from Buriganga and Turag, the two most polluted rivers running through the city;
- Promoting rainwater harvesting in Dhaka, (the city has an annual average rainfall rate about 1,854 mm);
- Reducing the amount of UFW through rehabilitation of the distribution system, better operation and maintenance and active leakage detection, including bulk metering;
- Lowering water prices for slums, through special consideration in the water tariff for compound housing.

Strategic directions to meet future wastewater management challenges

- Ensuring access to sanitation facilities in the slum areas by constructing sufficient public latrines and through proper hygiene education;
- Increasing the existing treatment capacity by increasing the number of connections to the sewer system and by building the capacity of the sewerage unit staff.

Strategic directions to meet future stormwater challenges

- Improving storm water discharge by improving and maintaining the stormwater drainage system;
- Managing solid waste by installing sufficient number of dustbins all over the city and conducting awareness campaigns, so that drains are less likely to be clogged by solid waste;
- Reducing surface water run-off by applying sustainable urban drainage systems, paving footpaths and public open places with semi permeable tiles, developing and maintaining a green belt around the current built up area, where urban agriculture can be practiced and by promoting rainwater harvesting.

Conclusion

Water and waste management problems are similar among developing countrycities. Accra and Dhaka share many common issues:for instance, an ever-increasing demand for water, weak systems of urban sanitation, seasonal fluctuation in urban population, undeveloped infrastructure and a poor institutional set-up.

Some strategic directions from Accra have been considered indeveloping the Integrated Urban Water Management (IUWRM) strategic plans for Dhaka city.Some strategic plans have been introduced to reduce the groundwater extraction rate, which isan urgent priority for Dhaka city. Huge investments are proposedto restore the most polluted localrivers (the Buriganga and Turag). If these rivers are restored, they become alternate sources of water, which wouldsignificantly decrease reliance on ground water. Moreover, the average annual rainfall of Dhaka is higher than in Accra, which means rainwater could becomea major renewable source of water for DWASA.

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Research and Scientific Data Management in Academic Institutions

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ABSTRACT: *The study of this paper is about research and scientific data management in academic institutions. Academic institutions are the creators of scientific research data, generated from both primary and secondary research. The objectives of the study are to identify research in academic institutions and identify how scientific raw data are managed, identify the data ownership in the research project, identify quality of raw data in research and identify the dissemination and publication process of the research results by academic institutions. The methodology of this study is based on secondary research that examines the theoretical framework of research in scientific disciplines. Data management addresses the key issues from raw data collection to recording in a hard and soft copy. Reputable academic institutions implement guidelines and policies for scientific data dissemination and publication. Finally, the suggestions with the concluding remarks have been made.*

KEYWORDS: *Research, Data Management, Record, Dissemination and Publication.*

Introduction

The topic of this study is research and scientific data management in academic institutions. Academic institutions are important creators of scientific research data in many disciplines. These data are generated from both primary and secondary research in all sciences and they are managed through collection, storage, validation, record, retention, protection and reporting/publication. Scientific data management varies institution to institution. Openness and dissemination of research results are very important in academic institutions. If scientific research data are not preserved and disseminated, future researchers interested in study of the subject cannot build on past knowledge and the general public cannot learn.

Quality of data, data ownership and data recording are the key issues that need to be addressed. Frequently funding agencies require a record of data to be kept for a certain period after the research project is completed. If data are not recorded in a digital format that allows access by others, then researchers will not be able to read/re-evaluate the results. This paper intends to address all these problems in a systematic manner. The paper has set some objectives and to serve the objectives, a methodology is designed to investigate the information in an orderly which is based on literature review/ secondary material. After having the current knowledge on the topic from the literature review, it will be determined whether there is any gap in the literature. Finally, findings will be determined from the detailed discussion followed by some suggestions and conclusion.

Objectives

The objectives of this article are to identify:

- the nature of research in academic institutions.
- how scientific raw data are managed.
- the ownership of data in research projects.
- the quality of raw data in research.
- the dissemination of research results.
- publication process of research results in academic institutions.

Methodology

The methodology is based on a review of the available literature/secondary material on research and scientific data management from recent articles, journals, books and reports.

Review of the Literature

New scientific research is often financed by funding agencies, which need to identify the people who will conduct the research. Among the group of people involved in the research project, one or more researchers are identified as the "principal investigator(s)" who are primarily responsible for issues related to data management. The issues include data ownership (who has the legal rights over the data?), data collection practice (collecting research data in a systematic and ethical manner), data storage (concerns for reconstruction of project

results and maintenance of confidentitality of human participants), recording (the physical process of collecting raw data in either a notebook/hardcopy and/or electronic copy in a computer), data protection (protecting written and electronic data from physical damage or theft), data retention (length of time project data need to be kept), data analysis (how raw data are chosen, evaluated, interpreted in a meaningful way with a significant conclusion so that other researchers and public can understand and use them), data sharing (whether data should be shared or not and how scientific data and research results are disseminated to other researchers and general public), and data reporting (publication of findings whether positive or negative) (Steneck, 2004).

The principal investigator, project director, relevant academic institutions and funding agencies may have the right to access and determine data where primary data should remain in the laboratory (University of Pittsburgh 2009).

There is no best method for data collection. Different types of research apply different data collection techniques. The important consideration that applies to data collection is integrity. For this, there should be an appropriate method, which makes data reliable. If the method is inappropriate or compromised by bias, any conclusion has little value. There is a common saying that 'garbage in, garbage out' (GIGO). In addition to the choice of method, researchers must pay attention to details to avoid mistakes. Appropriate consent must be obtained to collect data on human and animal subjects, to use biological specimens, to publish photographs and other copyrighted materials (Steneck, 2004).

In general, two primary data records are maintained in a laboratory: the methodology notebook and the experimental notebook. In the case of the University of California methodology and experimental notebooks and related data and records are the property of the university. The Principal Investigators (PIs) have final responsibility for the validity and quality of the data. All data must be stored in notebook and electronic copy form and retained in their laboratory for five years after the date when funding for a study ends (University of California, 2015). Protocol for recording data and preparing for publication of a research findings should meet these standards.

Data storage through electronic systems has some unique advantages relative to hard copies: rapid access to the data, fast read; low cost; ease of ability to archive the data, remove the data, and backup data by, for example, storing data on CDs (Straub 2004). Properly storing data is intended to safeguard data that may be needed in the future by other researchers who might wish to evaluate the results of your research and finally it is intended to protect researches in the event of legal allegations (US Department of Health and Human Services 2015).

Northwestern University has a policy on retention of university research data. Data must be retained for a minimum of three years after the financial report for the project period has been submitted. If research data are an intellectual property, then data must be kept for as long as necessary *(Northwestern University, 2012)*. There is no set amount of time for which data should be retained. Sponsoring institutions may have differing requirements. Some organizations may require that, after

the funding period, data should be retained a minimum of three years. When the decision has been made to end data retention, the data should be completely destroyed (US Department of Health and Human Services 2015).

Recording raw data should be done after data collection and validation. Recording should be durable, accessible and safe from tampering or falsification. After appropriate coding, electronic records allow researchers to access and compare information from different sources. There are numerous electronic data capture programs that allow researchers to enter, store and audit research data. There may be questions as to how recorded data are to be protected. For example, protection may involve use of unique user IDs and passwords and limited administrator access rights. The principal investigators should be required to update computer anti-virus protection and maintain up-to-date software. If the system is connected with the internet, use of firewalls and encryption may be required (US Department of Health and Human Services 2015).

Scientific research may employ a combination of hard copy and electronic record keeping balancing the risk and benefits of each. Guidelines and policies affect the validity of collected data that involve human and animal subjects and biological specimens. The record should include the information such as date and time, names of members who worked with the data, materials, instruments and software used and identification numbers to indicate the subjects. When transferring records from written to electronic format, use a double entry system to avoid error. To implement such a system, two researchers should enter all raw data into two different software programs, then cross-check the data to identify and remedy inconsistencies at the time of data entry (US Department of Health and Human Services 2015).

All data should be considered for data sharing and data should be made as widely and freely available as possible while safeguarding the privacy of participants, and protecting confidentiality and proprietary data (NIH 2003).

Researchers share the results of their work with colleagues and public in a variety of ways, such as laboratory meetings, seminars and professional meetings. Final results are communicated through scholarly journal articles and books. Public communication takes place through press releases, newspaper articles, public announcements and public testimony. All forms of publication should present full and fair description of the work, accurate report of the results and honest and open assessment (methods, results and discussions) of the findings (Steneck, 2004).

The Merriam-Webster Dictionary (2015) defines data as "factual information used as a basis for reasoning, discussion, or calculation". For example, scientific medical research data may include a patient's temperature reading, blood pressure reading, red-blood cell count etc. In recent developments, the sources of research data in digital form used by different institutions are human biological samples within the healthcare system, GIS data in climate and environmental research and employment information data used in social science research. The research data are variously owned by principal investigators, university and sponsoring organization/funding agency (US Department of Health and Human Services 2015).

Theoretical Framework

Research means detailed study of a subject, analysis, writing and reporting of results particularly in relation to scientific research in academic institutions. Research uses both primary and secondary data where primary data require collection of original research data through questionnaires, interviews and observation in social science, experiment and direct observation in engineering, medical and physical sciences. On the other hand, secondary research is literature/desk based and data are collected from published authorized documents and data sources. Research may be quantitative, qualitative or both. It depends on the researchers' approach – for example, choice of survey methodology and research questions, the type of claims researchers are willing to make, the topic/issue researchers are interested in and the skill of researchers. Quantitative research implies a systematic empirical investigation through statistical, mathematical, numerical data or computational techniques. On the other hand, qualitative research includes description, usually extracts from interviews, focus group discussion and observation *(Kenneth D. Bailey 1994)*.

Summary Observations and Findings

In many disciplines, such as medicine, mathematics, engineering, physical and social sciences scientific research projects are usually conducted by academic institutions under a funding agency. The principal investigators address complex issues related to data management.

The principal investigators and the academic institutions have rights to access and retain the data in research projects where primary data remain in the laboratory.

Some academic institutions have policy on retention of research data for a specified minimum number of years after the project period has been ended. If research data are intellectual property, then data are kept for as long as necessary.

The two primary forms of data records maintained in a laboratory are the methodology notebook and the experimental notebook, which are the property of the academic institutions. Principal investigators have final responsibility for the validity and quality of the data. Publication of a research work should meet various data management standards.

Data collectors should be concerned with integrity of the process, although there is no single best way to collect data. If the collection method is compromised by bias, the results will be of limited value ("garbage in, garbage out").

Research data can be disseminated and made freely available whle respecting privacy, confidentiality and proprietary issues. Dissemination takes many forms: laboratory meetings, seminars, professional meetings, scholarly journals, books, press releases, newspaper articles, public announcements and public testimony.

Suggestions

Principal investigators should address issues related to data management before conducting scientific research.

Principal investigators, academic institutions and funding agency should keep the legal rights and ownership of the work done.

Academic institutions should have a clear and written guideline and policy related to right of access, ownership and reporting/ publication of the data and results of scientific research.

Assessment of the results should be checked for research integrity to allow for publication.

Standards for publication of scientific research should be communicated by journals to authors wanting to publish results of their research.

Conclusions

Data management in social and scientific research raises varied issues. If they are not treated adequately, the reliability of research cannot be assured. As Bangladesh acquires more universities and more faculty members become interested in research, it becomes more important to assure responsible data management in Bangladesh universities. The responsibility of the principal investigator becomes more important. So too, the role of the university in determining adequate ethical procedures becomes more important. Typically, universities enjoy access and ownership rights with respect to research undertaken by their faculty members.

Over time, Bangladesh universities will have to prepare appropriate guidelines and policy related to research data management, and require all faculty members and other researchers to respect the guidelines and policy. This article has indicated the requirements of high quality data management in American universities and scholarly journals. While Bangladesh universities cannot copy these requirements precisely, they serve as a model of best practice for Bangladeshi universities.

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Design and Performance Analysis of Coaxial Probe-fed Rectangular Microstrip Patch Antenna (RMPA) for IEEE 802.11p Standard

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ABSTRACT: *In this paper a rectangular microstrip patch antenna (RMPA) has been designed with coaxial feeding for 5.9GHz resonant frequency. This frequency spectrum is known as Wave Access in Vehicular Environment (WAVE) or IEEE 802.11p. Performance of the RMPA has been analysed by the simulation tool CST Microwave Studio v.2012. Several performance parameters such as return loss, bandwidth, Voltage Standing Wave Ratio (VSWR), directivity, gain and radiation efficiency have been obtained by simulation. This antenna has shown desirable results after a few optimization of design specifications. Designed RMPA resonates at 5.93 GHz and bandwidth has been found as 0.1417 GHz which has fractional bandwidth of 2.39% and that covers IEEE 802.11p band. Directivity and gain obtained at resonant frequency are 5.52 dBi and -0.174 dB respectively. The proposed RMPA radiation efficiency was found as 26.93% and VSWR as 1.05. As an overall evaluation, this antenna's performance was found to beat a satisfactory level.*

KEYWORDS: RMPA, WAVE, IEEE 802.11p, CST MWS.

Introduction

In the fields of technology and information systems, wireless technology plays an important role in daily life. Nowadays, almost everybody is using smart phones, tablets or Wi-Fi enabled devices. One of the major components of these wireless devices is the antenna. Invention of smaller antennas is necessary to make wireless technology user friendly. The antenna should small enough to fit into a mobile phone or tablet casing. Moreover, radiation from the antenna can be harmful for humans as well as for the environment (Maria Blettner, Gabriele Berg 2000). Excessive radiation exposure is related to various diseases, so researchers are continuously innovating to design more compact and less harmful antennas (Maria Blettner, Gabriele Berg 2000).

Various types of antenna exist for wireless communication, such as the planar inverted-F antenna, horn antenna, helical antenna, patch antenna (Saunders & n-zavala, 2007, pp. 73-85). The patch antenna has become popular due to its low profile, low cost, low weight, compact size etc. (Singh & Tripathi, 2011). Many shapes (rectangular, circular, triangular) have been developed for patch antennas (Balanis, 2007). For these antennas,several feeding techniques are used (microstrip line feed, probe feed, aperture-coupled feed and proximity-coupled feed) (Balanis, 2007, pp. 813-814). All of them have specific advantages.

There are various wireless transmission protocols such as WiMAX, Wibree, Bluetooth, WLAN etc. (Mitra, 2009, pp. 19-21).WLAN is also called the IEEE 802.11 standard. It uses ISM band (5.25 GHz to 5.825 GHz) (Mitra, 2009, pp. 19-21). IEEE 802.11p is a protocol by which a moving vehicle can establish connection with another vehicle on the road (Eichler, 2007). It is an amendment of the WLAN standard. IEEE 802.11p standard uses the 5.9GHz band, which operates within frequency range of 5.85GHz to 5.925GHz (Eichler, 2007). According to (Eichler, 2007) this standard was previously known as Dedicated Short Range Communication (DSRC), and it might be popular in the near future.

In this paper, based on the amendment of WLAN, a rectangular microstrip patch antenna with coaxial probe feeding technique has been designed, and the performance of the RMPA has been analysed.

Antenna Design

For designing the antenna, a resonance frequency and substrate material have been selected. Then, by using associated formulas, antenna dimensions have been calculated in MATLAB. A code has been developed for this purpose.The proposed RMPA has been designed on a Fiber Reinforced (FR-4) glossy substrate, which has relative permitivity of 4.3 and loss tangent of 0.025. For an antenna patch, this becomes the perfect electric conductor (PEC) material. The ground plane also has been made of the PEC. The associated formulas are given below.

The width of the patch can be calculated by equation (1) (Majumder, April, 2013; Balanis, 2007, pp. 727-730)

$$W = \frac{c}{2f_0\sqrt{(\epsilon_r + 1)/2}} \quad \ldots\ldots\ldots (1)$$

The effective relative permitivity of the substrate material has been calculated by equation (2) given at (Balanis, 2007, pp. 727-730; Majumder, April, 2013; Pozar, 2012, pp. 147-150).

$$\epsilon_{reff} = \frac{\epsilon_r + 1}{2} + \frac{\epsilon_r - 1}{2}\left[1 + 12\left(\frac{h}{W}\right)\right]^{-1/2} \dots\dots\dots (2)$$

Extended length of the patch can be calculated by equation (3), which is taken from (Majumder, April, 2013; Balanis, 2007, pp. 727-730).

$$\Delta L = \frac{0.412h\left(\left(\epsilon_{reff} + 0.3\right)\left(\frac{W}{h} + 0.264\right)\right)}{\left(\epsilon_{reff} - 0.258\right)\left(\frac{W}{h} + 0.8\right)} \dots\dots\dots (3)$$

According to (Majumder, April, 2013; Balanis, 2007, pp. 727-730)the actual length of the patch can be given as follows,

$$L = \frac{\lambda_o}{2} - 2\Delta L \dots\dots\dots (4)$$

Feeding position of the coaxial cable can be obtained by using following equations give at (Majumder, April, 2013).

$$X_f = \frac{L}{2\sqrt{\epsilon_{reff}}} \dots\dots\dots (5)$$

$$Y_f = \frac{W}{2} \dots\dots\dots (6)$$

From (Majumder, April, 2013) ground dimension of the RMPA also found as,

$$L_g = 6h + L \dots\dots\dots (7)$$

$$W_g = 6h + W \dots\dots\dots (8)$$

The proposed RMPA is shown in Figure 1(a) and 1(b). A pin of thePEC is connected through the substrate with the patch; and the coaxial port is made of a dielectric material, teflon, which has been shown in Figure 1(b). The patch, substrate, width and length of the RMPA are shown in Figure 1(a). Figure 1(b) shows the coaxial feed, which is connected with the ground plane. The probe has been inserted inside the substrate.

Figure 1a: Perspective view of RMPA

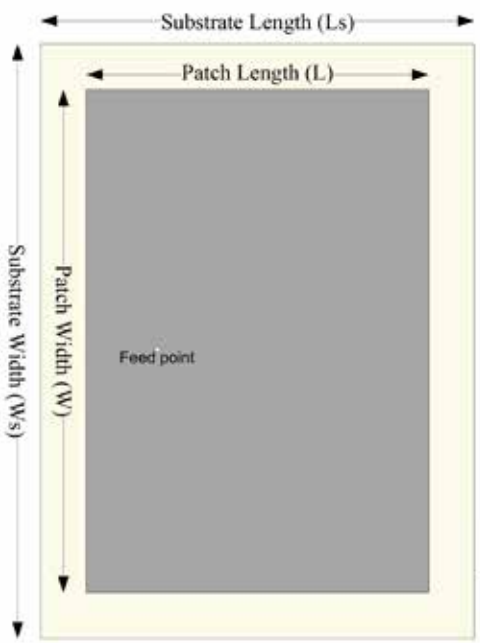


Figure 1b: Bottom view of RMPA

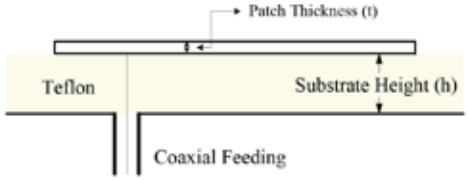


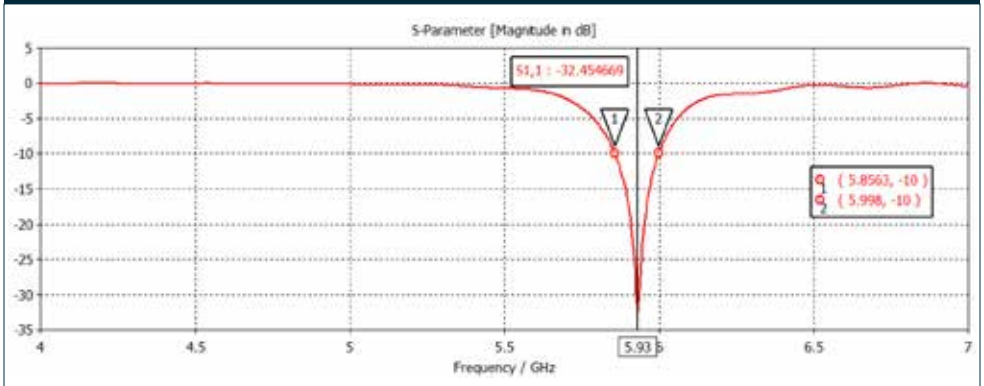
Table 1: RMPA Design Specfications			
Parameter	**Value**	**Unit**	**Material**
Resonant Frequency (fr)	5.9	GHz	-
Substrate Relative Permittivity (εr)	4.3		-
Patch Width (W)	15.62	mm	PEC
Patch Length (L)	11.66	mm	
Patch Thickness (t)	0.035	mm	
Substrate Width (Ws)	18.62	mm	FR-4 (lossy)
Substrate Length (Ls)	14.6	mm	
Substrate Height (h)	0.5	mm	

Antenna design specificationsare given in Table I. The distance between the patch and the ground plane has been taken as 0.5 mm which is denoted by h. Ground dimensions are the same as substrate dimensions except thickness. The ground plane has been created as an extended sheet of PEC from the substrate along the negative vertical axis. In this design,wave-port has been selected; and the simulation boundary is set as 4GHz to 7GHz.

Simulation and Results

Based on the design specification, a RMPA has been designed by using CST MWS 2012. The RMPA performance has been simulated and the parameters of antenna performance have been studied. Return loss plot, VSWR plot, Smith chart, polar plot, 3D radiation plot and surface current, H-field & E-field distribution on the patch are shown in the following figures.

Figure 2: Return Loss Plot of RMPA



From Fig.2 the return loss of the RMPA has been found as -32.45 dB at resonant frequency (f_R) 5.93 GHz. At -10dB it has been found that the lower frequency (f_L) is 5.8563 GHz and higher frequency (f_H) is 5.998 GHz. This is 0.1417 GHz bandwidth, which is sufficient to cover IEEE 802.11p band. From this figure, according to (Balanis, 2007, pp. 869-872), thefractional bandwidth (fBW)can be calculated as follows:

$$fBW = \frac{f_H - f_L}{f_R} = \frac{(5.998 - 5.8563)GHz}{5.93\,GHz} \times 100 = 2.39\%$$

Figure 3: VSWR Plot of RMPA

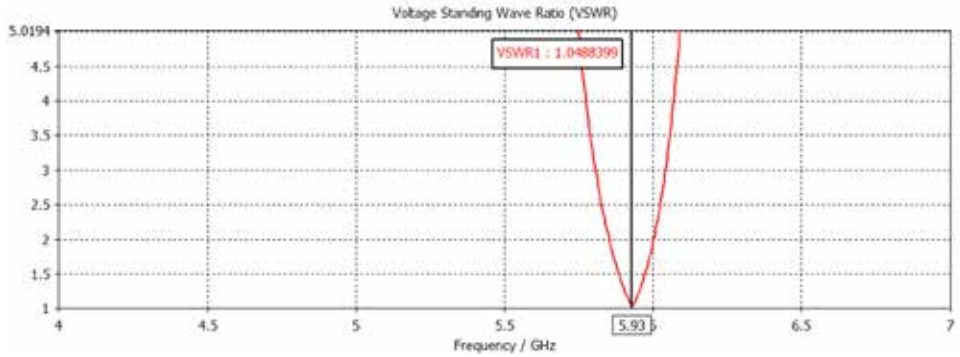
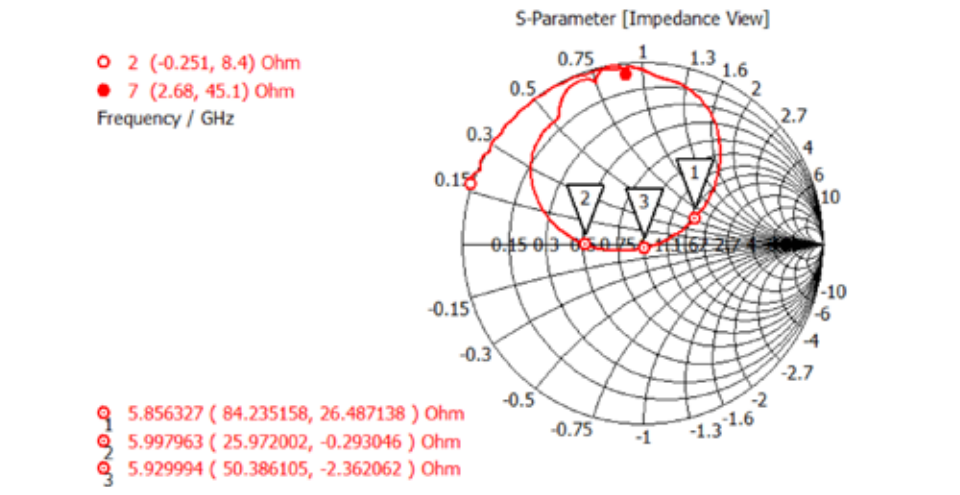


Fig.3 shows the VSWR at resonant frequency which is1.05 and is lower than 2. This result is good enough to continue the simulation.

Figure 4: Smith Chart of RMPA



The Smith Chart of this RMPA operating for the frequency between 2GHz to 7GHz is shown in Figure 4. Curve marker 3 shows that at resonant frequency impedance matches with characteristics impedance 50 Ohm.

The far-field polar plot of the proposed RMPA is shown in Figure 5(a). From the figure, the main lobe magnitude has been found as 5.5 dBi and angular width at 3dB which is 100.9 degree. Figure 5(b) shows the H-plane polar plot of RMPA at 5.9 GHz. In that case, the angular width is 87.2 degree at 3dB and the main lobe magnitude is 5.5dBi.

Figure 5a: E-Plane Polar Plot of RMPA at 5.9GHz (Phi = 0 degree)

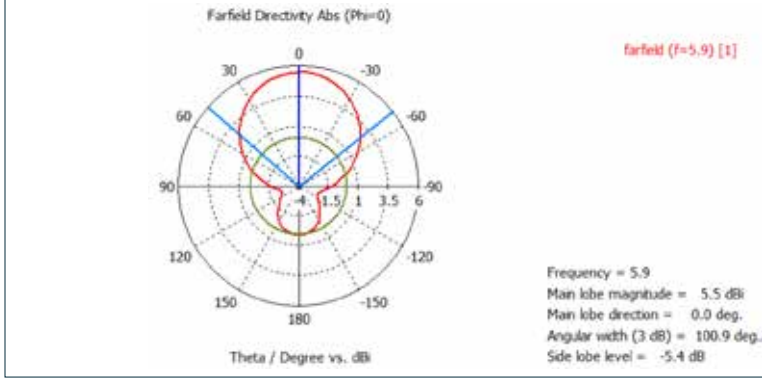


Figure 5b: H-Plane Polar Plot of RMPA at 5.9GHz (Phi = 90 degree)

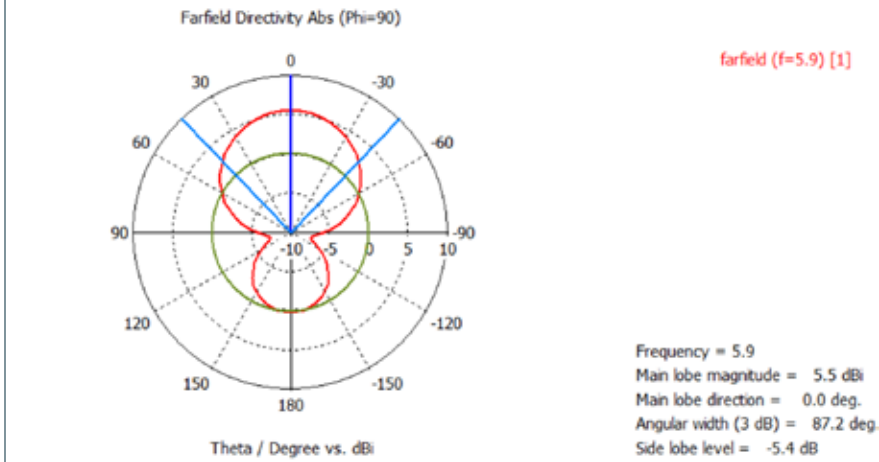
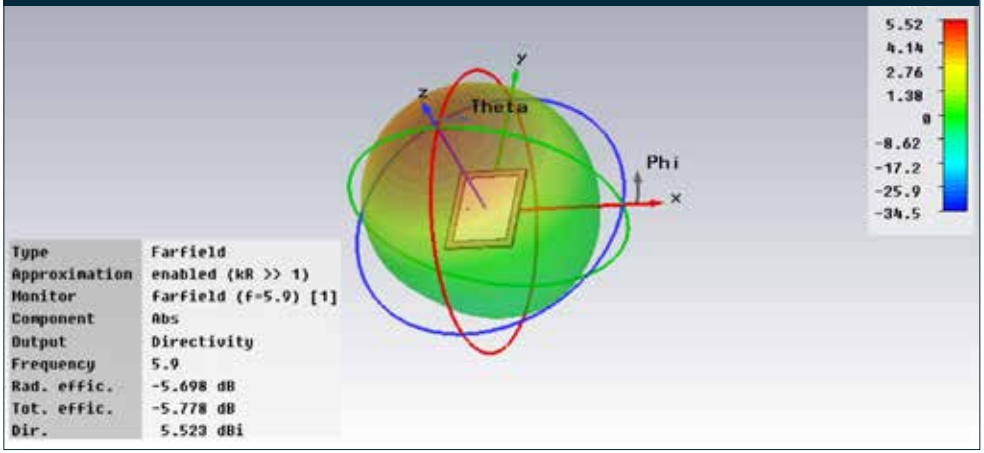
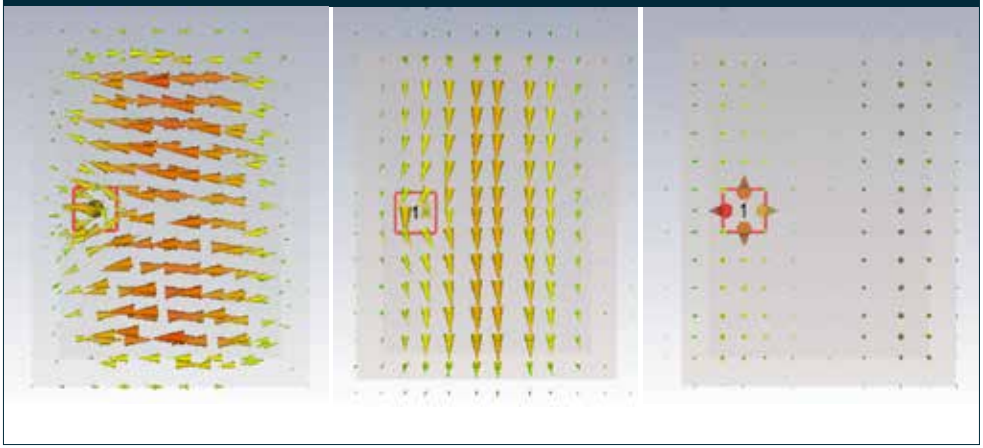


Figure 6: Radiation Pattern of RMPA at 5.9 GHz



Figures 7a: Surface Current 7b: H-Field and 7c: E-Field on RMPA at 5.9 GHz



The radiation pattern of the proposed RMPA at 5.9 GHz (Balanis, 2007; Mitra, 2009) is shown in Figure 6. In that case directivity is 5.52 dBi. Maximum radiation has occurred on the top of the RMPA.

Figure 7(a) shows the surface current density at 5.9 GHz resonant frequency. Figure 7(b) shows the H-field and Figure 7(c) shows the E-field density on the top of the RMPA.

All results are tabulated in Table 2.

The conclusion from Table II is that the proposed RMPA shows acceptable antenna performance.

Table 2: Simulated Results of RMPA	
Parameter	**Result**
Resonant Frequency	5.93 GHz
Return Loss	-32.45 dB
Lower Frequency	5.856 GHz
Upper Frequency	5.998 GHz
Bandwidth	141.7 MHz
Fractional Bandwidth	2.39%
VSWR	1.05
Radiation Efficiency	26.93%
Gain	- 0.17 dB
Directivity	5.52 dBi

Conclusions

In this paper, a simple coaxial-probe fed rectangularmicrostrip patch antenna has been designed by the simulation tool CST Microwave Studiov.2012. The proposed antenna resonates at 5.93 GHz and it fulfills the requirements of this project. It showed reasonable results, useful for compact wireless devices. Almost new IEEE 802.11p protocol requirements have been obtained by this proposed antenna. By making further optimization, such as inserting slot, truncating ground, by using metamaterials, and by introducing fractalsin the patch, it maybe possible to use this proposed compact RMPA for multiband operations. The authors would like to continue this project for further improvement through modifications.

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Glossary

IEEE 802.11p

IEEE 802.11p is an approved amendment to the IEEE 802.11 standard to add wireless access in vehicular environments (WAVE), a vehicular communication system. It defines enhancements to 802.11 (the basis of products marketed as Wi-Fi) required to support Intelligent Transportation Systems (ITS) applications. This includes data exchange between high-speed vehicles and between the vehicles and the roadside infrastructure in the licensed ITS band of 5.9 GHz (5.85-5.925 GHz). IEEE 1609 is a higher layer standard based on the IEEE 802.11p.

https://en.wikipedia.org/wiki/IEEE_802.11p#cite_note-1

Return loss

Return loss is the loss of power in the signal returned or reflected by a discontinuity in a transmission line or optical fiber. This discontinuity can be a mismatch with the terminating load or with a device inserted in the line. It is usually expressed as a ratio in decibels (dB). A high return loss is desirable and results in a lower insertion loss. If return loss is 0 dB, then all the power is reflected from the antenna and nothing is radiated. If return loss is -10 dB, this implies that if 3 dB of power is delivered to the antenna, -7 dB is the reflected power. The remainder of the power was accepted by or delivered to the antenna. This accepted power is either radiated or absorbed as losses within the antenna.

https://en.wikipedia.org/wiki/Return_loss

VSWR

Voltage Standing Wave Ratio (VSWR) is also referred to as Standing Wave Ratio (SWR). VSWR is a function of the reflection coefficient or return loss (S11), which describes the power reflected from the antenna. The VSWR is always a real and positive number for antennas. The smaller the VSWR is, the better the antenna is matched to the transmission line and the more power is delivered to the antenna. The minimum VSWR is 1.0. In this case, no power is reflected from the antenna, which is ideal

http://www.antenna-theory.com/definitions/vswr.php

The Smith chart

The Smith chart is a graphical aid or for electrical and electronics engineers specializing in radio frequency (RF) engineering to assist in solving problems with transmission lines and matching circuits. It is a circular plot with a lot of interlaced circles on it to demonstrate of how many RF parameters (impedances, admittances, reflection coefficients, etc) behave at one or more frequencies.

https://en.wikipedia.org/wiki/Smith_chart

Polar Plot or Polar coordinate system

Polar coordinate system is a two-dimensional coordinate system in which each point on a plane is determined by a distance from a reference point and an angle from a reference direction.

WiMAX

WiMAX (Worldwide Interoperability for Microwave Access) is a wireless industry coalition dedicated to the advancement of IEEE 802.16 standards for broadband wireless access (BWA) networks

WLAN

A wireless local area network (WLAN) is a wireless computer network that links two or more devices using a wireless distribution method (often spread-spectrum or OFDM radio) within a limited area such as a home, school, computer laboratory, or office building.

Wibree

Wibree, also called "Baby Bluetooth," is a low-power wireless local area network (WLAN) technology that facilitates interoperability among mobile and portable consumer devices

E-Plane

The E-plane is any plane that contains the Electric field and the direction of maximum radiation from the antenna.

H-Plane

The H-plane is a plane that contains the Magnetic field and the direction of maximum radiation fro

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.

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