Innovation: Towards a sustainable future

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1 Introduction

Bangladesh is an enigma. This youngest south Asian nation has been progressing from war devastation from 1971. The GDP has more than tripled in real terms, food production has increased three-fold, the population growth rate has declined from around 2.9% per annum in 1974 to 1.4% in 2006 and the country is now largely food secured. According to Asian Development Bank, eradicating poverty in Bangladesh in the current generation is no longer a dream.

However, in a country with a huge population and scanty and depleting resource base, it is not easy to strike a balance between economic growth and sustainable development. The arts of measuring the 21st-century economy are Innovation. But, innovation is not a zero sum game— it grows the economic pie and gives more people a seat at the table. To measure that growth, it is important to update and adapt metrics to innovation. Bangladesh has some "Made in Bangladesh" innovations e.g. micro-credit, non-formal education, oral rehydration therapy, low-cost birth mat etc. contributed to the improvements to reach our MDG targets (The Economist, May 2013). Still innovative technology cannot play a vital role in shaping Bangladesh's future. The average value for Bangladesh Innovations index from 2011 to 2014 was 25.78 points with a minimum of 24.4 points in 2014 and a maximum of 28.1 points in 2011. The Global Innovation Index includes two sub-indices: the Innovation Input Sub-Index and the Innovation Output Sub-Index. The first sub-index is based on five pillars: Institutions, Human capital and research, Infrastructure, Market sophistication, and Business sophistication. The second sub-index is based on two pillars: Knowledge and technology outputs and Creative outputs. Simple, affordable technologies enable the rural poor of Bangladesh to become entrepreneurs, creating a path out of poverty that is both sustainable and replicable. This paper explores some commendable innovations on sectoral basis.

2 Agriculture

Agriculture is an important engine for economic growth of Bangladesh. Once a food-deficit country with an extremely unfavorable land–man ratio is now runs a food surplus. The country has managed to triple its rice production in the 40 years since independence. However, feeding such a rapidly growing population, especially given scarce land and water resources and rising climate threats, requires new strategies, technologies and innovation. The country opted to pursue policy of continued agricultural growth through widespread diffusion of Green Revolution technology with corresponding support of the provision of modern inputs, such as chemical fertilizers, pesticides, irrigation, credit, product procurement, storage, and marketing facilities over the past four decades. As a result, land use intensity increased sharply to 174.7%

in 1998/99 from its initial level of 143.9% in 1968/69 with corresponding increases in input use rates (Alauddin and Tisdell, 1991; BBS, 2001).

Fertilizers, improved seeds, cropping techniques are potential mechanisms for increasing yields. The Bangladesh Rice Research Institute (BRRI) has been continuing its research activities to develop hybrid varieties favorable to local agro-ecological and climatic situations. The focus of the BRRI work is on saline tolerant varieties of rice for the Southern part and flash flood or drought tolerant varieties for the Northern part. BARI is also working with wheat, maize, oilseeds and pulses for both the South (Agro-ecologically constrained) and the North (economically depressed).

Nitrogen is required in large quantities for plants to grow, since it is the basic constituent of proteins, and nucleic acids. Bio fertilizer is a new approach to avoid chemical fertilizer as an alternative source of N-fertilizer. N-Bio fertilizers can provide 25-30% of chemical fertilizer equivalent N. They are made from coconut dust, earthworm compost, and green manure.

Farmers have different types of information needs during each stage, ranging from weather forecasts, pest attacks, inputs (seeds and fertilizer), improved cultivation practices, pest and disease management and prices. ICT-based agricultural extension and market information systems are a unique opportunity to facilitate technological adoption through mobile phone coverage. Introduction of cell phone have been eliminated middlemen. The farmer can now directly get firsthand information on market prices from miles away. Besides, institutional credit played a supporting role. As a result, the rate of adoption of HYVs improved rapidly.

Low lying land mass and high levels of precipitation creates potentiality for aquaculture and the importance of fisheries. Fresh water pearl cultivation is an economic viable sector. Aquaculture is playing a role in biofuel production, e.g. algal biomass, using of processing fish discards and by-products. Polyculture of shrimps or prawn with commercially important brackish water fin-fishes improve soil, water, and productivity of gher fishery. Local people adopted highly innovative hatchery techniques have allowed to reduce fuel and electricity costs, use fertilized water for rice production, avoid feed loss and induce spawning. An incubation system innovated by route level farmers that recycles water through a bio-filter.

2.1 Irrigation

Until 1950's farmers used only traditional means of irrigation, swing basket, and dhone. Since 1988, the Government of Bangladesh had cut import duties on small diesel engines from 50 to 0 percent, and removed a ban on non-aid-funded import of engines for irrigation created an enormous opportunity. Few irrigation technological innovations have been taken place and disseminated in recent years with the collaboration of government, semi-government and non-government organizations (NGOs). These are automated canal and piped water delivery systems; set and automated sprinkle irrigation; Alternative Wet and Dry (AWD) method, pre-paid meter irrigation system, micro-irrigation including surface and sub-surface drip systems.

2.1.1 AWD method

Boro rice, a traditional variety in Bangladesh, needs entirely irrigated field. Alternate wet and drying AWD method has saved water for irrigation in Boro rice cultivation. Mostly underground water is used by the farmers. Research has been conducted through BRRI-IRRI collaboration to develop water saving techniques for by the AWD method. It involves installation of a perforated pipe (preferably PVC pipe) in rice field to allow observation of water level. Now, AWD has been widely adopted in China, northwest India, and Philippines. The AWD fields had the same yield as continuous flooding, but this new method saved 16-24 per cent water costs and 20-25 percent production costs.

2.1.2 Treadle Pump

The treadle pump is developed by Rangpur-Dinajpur Rural Services. A treadle pump is a simple low-cost manual (foot-operated) pump that can lift water from shallow groundwater sources or surface water bodies. Local made other useful tools are Corn shellers, rippers, threshers, straw-bundle cutting machines, and seeders.

2.1.3 Buried Pipe Irrigation:

Generally, surface drains are used for irrigation purpose. Such surface drains are made with brick lining or concrete lining or just ordinary earthen drains. The first two systems are not economic, while the third one is required to be maintained every year during irrigation time. In these systems, much water is wasted (due to evaporation/percolation). Buried Pipe Irrigation System is economic and it does not require annual maintenance. In this system, total use of the command area of deep tube well irrigation is possible which is unthinkable in surface irrigation.

2.2 Adaptation to impacts of climate change

No doubt that climate changing is a reality for Bangladesh. Changing temperature, pattern of rainfall, sea level rise, salinity intrusion are the major threats to agriculture. Climate variability and change has the potential to significantly affect Bangladesh's efforts to provide food to a growing nation. Government adopted integrated framework used to estimating the hydrologic and biophysical impacts of climate change, the macro-economic and household-level impacts and an effective method for assessing a variety of adaptation practices and policies. Morever, construction of modern silos will allow storage handling of large volumes of food grains, particularly rice, for two to three years. The steel-bolted silos will have temperature control and fumigation systems, automated mechanical handling, and a central computerized control system. Without any preservatives only humidity and moisture control allows to preserve the food.

The experiences and innovations of stress-tolerant varieties or in the adaptive farming practices are no less useful for other parts of the world. Success in Bangladesh so far and in future may

stimulate similar achievements in other countries, especially deltas around the world. Several innovative or indigenous approaches are initiatives to adopt with changing climate.

2.2.1 Zero or minimum tillage crop and system

Practice is going on to cultivate potato, aroid and groundnut with water hyacinth and straw mulch with Zero or minimum tillage. This practice is done on mostly medium high land in flood-prone areas during the rabi season. Farmers sow seeds on moist soil just after the recession of flood water. The land is then mulched with water hyacinth of about 30cm thick. The mulching conserves soil moisture and decreases evaporation from the soil. In some cases, after the harvesting of the t. aman crop, the delay in the recession of flood water results in excessive soil moisture and unsuitable conditions for planting. To get rid of this situation, adaptation option broadcasts mustard, mashkalai or khesari in the t. aman field 10–15 days before harvest using zero tillage approaches to generate an extra crop.

Maize is a crop that grows all year. The yield of maize is comparatively higher than rice, wheat or any other cereal crops. In the Barind tract areas, farmers often harvest and keep t. aman rice on the field to dry for two to three weeks. This is then collected for threshing to separate the rice from the straw. During this time, the soil loses its moisture due to the high rate of evaporation and the land becomes hard. This situation makes it difficult for farmers to plough the land and therefore in many cases the land remains fallow. Farmers can easily cultivate maize by using the existing soil moisture in the fallow land during the rabi season following a zero-tillage system.

2.2.2 Modified sorjan system (zuzubi garden) with vegetable cultivation in char land

Flood waters remain on crop fields and char lands for an extended period of time. Vegetables and fruits cannot be grown in the absence of uplands. Most of the char lands remain fallow after the recession of flood water during the rabi and kharif-1 season. A modified sorjan system with vegetable cultivation can help to increase production in these places.

2.2.3 Dhap Cultivation or Floating method

Dhap Cultivation or Floating method is useful for low lying with salinity and water logged, erratic rainfall in Bangladesh. Floating platform or organic bed is prepared using layers of water hyacinth, and allowed to decompose fully before packing it with ash and plant compost to form a fertile cultivation ground for a wide range of crops and seedlings like spices and vegetables. Dhap residues, after floating cultivation, are used on land plots to raise homestead vegetable gardens.

2.2.4 Cultivating foxtail millet (koan) in char land

Most char lands remain fallow after recession of flood water. Foxtail millet (kaon) is a low-cost cereal crop. It is a drought-tolerant, short duration crop that can be grown with minimum tillage during the rabi season immediately after the recession of flood water.

2.2.5 Chickpea cultivation using a priming technique

Typically, chickpea seeds are directly cultivated in the field. However, this is not optimal under low soil-moisture conditions. Through priming technique, seeds are soaked and chickpea seeds are spread in a shaded place where there is enough air movement for air drying before sowing in the field. Good tillage is essential for moisture preservation. Primed seeds will be germinated after four to five days.

2.2.6 Supplementary irrigation from mini ponds

From October to May, rainfall is very low in Bangladesh. Winter vegetables require irrigation for maintaining soil moisture. Supplementary irrigation can play a vital role in production of vegetables. In the absence of water for irrigation, rainwater harvesting in mini ponds is an alternative for supplementary irrigation during the dry period. These mini ponds are typically excavated within the crop land. Farmers use comparatively lower areas to dig these ponds. Typically, rainwater is harvested or surface water is diverted into mini ponds during the monsoon.

2.2.7 Year-round homestead vegetable cultivation

Generally root level villagers have small land around the homestead. Farmers can easily use this fallow land for cultivating vegetables around the year to fulfill family requirements. Homestead vegetable cultivation is an employment-generation activity for women and children, a source of additional income and also increases vegetable and fruit consumption.

2.2.8 Aquaculture

Bangladesh's is one of the largest fresh water fishery sectors of the world. Agriculture and fisheries sector is largest consumer of water, is highly vulnerable due to its direct dependence on climate parameters. To expand and diversify aquaculture in the coastal saline areas that are likely to increase by climate change, research effort on captive breeding and seed production of important brackish water finfish species has been a success. Short cycle aquaculture is a valuable approach, using new species or strains and new technologies or management practices to fit into seasonal opportunities. Concurrent mud-crab fattening in the ponds and cases integration with fish has been found a potential technology that can not only adapt well with climate change impact but also maximize land utilization, increase income and provide household nutrition. In this technique, crab-fattening can be at 6-8 times higher than fattening in pond only. Integrated

agriculture-aquaculture (IAA) system is an important means of diversifying and improving the coastal farm productivity both in wet and dry season's saline condition. Improved management in shrimp culture during the high saline period followed by cultivating HYVs of Aman rice (BR 23, BRRI dhan 40 and 41) along with fish and prawn in wet season has been found an excellent farming system. Researchers find hydroponic agriculture is a promising cropping farming system in areas vulnerable to water logging. This agriculture practice can productively be utilized in coastal areas, using suitable salinity tolerant vegetables and in integrating with pen aquaculture.

2.3 Jute

Numerous products are produced from the jute plant and stalks, including fashion, apparel, fabric, yarn, rope, industrial, handicraft, agricultural, and others. In addition to jute's commercial uses, jute leaves are eatable. People who cook with jute leaves use them in soups, stews, curries, vegetable dishes, and sometimes tisanes or teas. As a promotional approach the government has passed a mandatory jute packaging law (Law 53 in 2010).

2.3.1 Fibre

Jute is a kind of cheap and abundant natural vegetable fiber, but due to its rough nature it is traditionally only used as gunnysacks. After 8 years of research, new innovation made a breakthrough in applying natural jute into the textile industry. jute is second only to cotton in the amount produced among all the natural vegetable fibers. It is renewable, degradable, and green. Hessian, Hand loom, power loom and knitted both jute and jute blends, e.g. Jutex commercialized. Bio-engineering technologies facilitate planting jute in waste land, such as marshes and infertile land. Planting jute could even convert waste land into arable land. Using jute can reduce the demand for cotton and alleviate the pressure cotton fields have over agricultural land, and planting jute could absorb a certain amount of CO_2 from the air. Jute fibers and stalks are using in pulp and paper products also.

2.3.2 Industrial Application

Jutin, for example, is an innovative building material based on jute fiber and which is lightweight, heat-insulating, and rust-proof. By mixing it with resin, it can be transformed into a sustainable and affordable building substance to construct shelters in poor countries and disaster-stricken areas. Greenovation Technologies, the Bangladeshi firm creating jutin, took the top award at the 2012 Global Innovation through Science and Technology "I Dare" business plan competition. The firm is exploring the most cost-effective machinery and method for mass production prior to global launch.

Bio-composite is another industrial application of diversified jute products. Jute is blended with other materials and incorporated into bio-composite for automotive interiors (fabric and body parts) by manufacturers including Mercedes Benz, Daimler Chrysler, Ford Motors, Toyota,

Hyundai, and Suzuki. Estimated demand for bio-composites is up to 10 million tons of jute annually.

2.3.3 Geotextile (JGT)

Geotextiles used for civil engineering, coastal engineering, and soil erosion control are traditionally made of synthetic materials. Nowadays, jute geotextiles are favored over synthetic since the raw materials are plentiful and renewable, the jute enhances soil nutrition when it biodegrades, and jute geotextiles are less expensive. It is easy to blend with other natural material and synthetic fibres. Initially it has got the high strength and non-hazardous properties. Sometimes, these were treated with bitumen to increase its tensile strength.

Prevention riverbank erosion and mudslide from hills and renovation of rural roads can possible with jute geo textiles. Jute geo textile is a kind of gunny sheet that gets mixed with soil after rotting and creates a kind of strength in soil that resisting landslide. JGT basically acts as a catalyst or a change agent in improving the engineering behavior of soil and is required for limited period of time, beyond which JGT has a redundant catalytic function. Due to their short life span, JGTs are used as separator, vegetation growing mesh on slopes or as vertical drains. The application areas for JGT were identified as the filtration in cross plane flow, separation of dissimilar materials, reinforcement of weak soils and in-plane flow. It is also a renewable source of energy as natural biomass. These are using increase stability of rural roads.

3 Energy

Bangladesh has major problems with energy crisis, persisting poverty and environmental degradation. With only 49% of Bangladeshis having access to electricity, the per capita energy use is only 180 kWh. The proven reserve of natural gas which is the principal source of non-renewable energy of the country is gradually depleting. Considering this, the Government has taken a range of steps to diversify energy sources. In the private industries, most of the gas-fired boilers are old and inefficient, and waste heat from captive generators is mostly not utilized. Efficient Rice Husk Parboiling Programme replacing inefficient boiler is attaining ‘green energies’ label.

The Government has given importance to LNG (Liquid Natural Gas) alongside gas, oil, coal, CNG (Compressed Natural Gas) and LPG (Liquefied Petroleum Gas). In order to reduce the air pollution in Dhaka and other cities, the Government has given emphasis on the best possible use of environmental friendly fuel CNG in transport sectors. The use of CNG in all types of road and riverine transports replacing motor spirit and diesel will be commercialized.

3.1 Biogas

Bangladesh has given birth to one of most successful models to replicate renewable energy target (RET). Methane from bio-waste is one major source of Green House Gas (GHG) emissions.

Hence biomass, a potential source of gas generating from global warming, is being composted to produce organic fertilizer. A total of 5 indigenous biomass energy (bagasse, dung, firewood, husk and plant residue) sources are explored. Traditionally cow dung is used a fuel. Biogas, which is a by-product of the process, is used in rural areas to cook food and run small and cottage industries like bakeries and workshops. After producing gas, the cow dung is moved to the outlet chamber under the gas pressure and incoming new biomass materials and is deposited in a pit as a very good quality fertilizer ready to use in the field. It is best for soil, environmental health and agricultural productivity management. Bangladesh has a potential to generate at least 1000 MW electricity from bioenergy. Biogas technology not only generating cooking gas, but also for generating pure methane gas which can used for running vehicles, power pumps and other electronic equipment.

3.2 Biofuel: Briquette

Briquettes produced from the husks of paddy are a good substitute for firewood. Briquettes burn with a steady flame for a long period and produce almost no smoke and odor. This biofuel is being used in bitumen heating in road development works by Local Government and Engineering Division. Fuel cost has been reduced by 20-25% by using briquettes instead of firewood. Large scale use of briquettes will resist deforestation to a great extent.

3.3 Energy- mix

Demand of total energy in the rural areas is to be met by a mix of bio-mass fuel, commercial fuels and the renewable energy technologies and their composition would vary from place to place.

3.4 Brick burning-modern process

Unavailability of stone aggregate, brick becomes the main building material for the construction industry of Bangladesh. Despite highly polluting and energy-intensive features, the Fixed Chimney Kiln (FCK) dominates the brick sector in Bangladesh. Innovative technologies as the Improved Kilns are substantially cleaner, consuming less energy and emitting lower levels of pollutants and greenhouse gases. Various types of carbonaceous materials can be used as internal fuel, such as mixing coal with bricks to form green bricks in order to reduce pollution. Waste with calorific value can be mixed with green bricks. Pulverization coals are used as improved fuel. A graded coal mixture of various particle sizes such as 50% percent or even more of powdered coal can optimize the efficiency and pollution levels from coal burning. The heat loss is caused by air leakage from numerous points in the kiln and by conduction through sidewalls and to the top. These losses can be minimized through improvements in current operating practices, as follows:

• Plastering the interior kiln wall to avoid air leakage through the sidewalls and provide better insulation.

• Insulating the kiln top using a soil and coal ash mixture to reduce heat loss through the top.

• Adding coal ash to the kiln bottom and loading burned bricks as the first layer to reduce ground-level heat loss because burned bricks are better insulators than green bricks.

• Using better-dried green bricks to reduce heat loss caused by brick moisture

3.5 Energy Efficiency

Energy Efficiency offers a powerful and cost effective tool for achieving a sustainable energy in future. Improvements in energy efficiency can reduce the need for investment in energy infrastructure, cut energy bills, increase competitiveness and improve consumer welfare. Environmental benefits can also be achieved by the reduction of greenhouse gases emissions and local air pollution. For example, when a compact florescent light (CFL) bulb uses less energy than an incandescent bulb to produce the same amount of light, the CFL is considered to be more energy efficient.

3.6 Inland water transport

Environment friendly energy like gas (CNG) is using in marine diesel engines. Such initiatives will certainly reduce carbon footprints and help climate change. Inland water transport is considered more energy efficient, emitting less CO_2 per ton-km performed, compared to transport modes like road or rail.

To keep rivers and estuaries including large canals, constant dredging is essential in Bangladesh every year. Especially after monsoon, large sand banks require to be dredged out. CNG powered diesel engines may be used in all dredgers.

4 Health

Bangladesh is an exceptional health performer. National water and sanitation coverage in Bangladesh has improved significantly over the last few years. Still there are pockets of areas that have received very little attention. Water and sanitation coverage remain much below the basic minimum level in areas like Chittagong Hill Tracts, river islands, hoar areas, urban slums, and tea gardens. Continuous research and development activities are conducted to improve existing technologies and to develop new technologies. Depending on community choice appropriate sanitation technologies may include twin off-set pit pour flush latrines, individual or community type ecological sanitation facilities and community septic tank systems. Community based Rain Water Harvesting System (RWHS) innovated by DPHE serve 3 to 5 families i.e. about 25 to 30 users for drinking and cooking purpose.

4.1 Oral Rehydration Solution

In the early 1970s, ICDDR,B researchers made a discovery that still stands among the most important medical innovations in the 20th century—oral rehydration solution (ORS). The

development and global application of ORS has decreased the death rates from diarrhoeal diseases by more than half in the last 30 years. UNICEF now distributes approximately 500 million ORS sachets each year to over 60 countries. Other ground breaking innovations are zinc, mixed with ORS, dramatically reduces fatality rates from diarrhoea.

4.2 Tara pump

Rural water through hand-pumps from shallow ground water aquifers, which is based on a service level where one hand pump serves on average 20 people, or roughly about 3 families, is a major success story for Bangladesh. The Tara Pump is a "Direct Action Pump for Low Lift Wells" initially developed in Bangladesh as a measure to counteract the dropping water table that exceeded the range for suction pumps in the year of 1984. The pump use for drinking water and limited use for irrigating gardens. It uses a buoyant pump rod that helps to reduce the forces on the handle. It is not designed for heavy-duty use, and can serve small communities of 100 persons. The maximum recommended lift is 15 m. The Tara Pump is a public domain pump defined by RWSN specifications and Indian Standards. It is fully corrosion resistant and is easy to install and has excellent potential for community-based maintenance. Some part of the country (particularly Rajshahi zone), facing acute lowering of water table exceeding 100 ft. In these areas Tara-dev is not suitable. So Mark-3 and Afridev pump capable of abstracting water having water table around 150 ft.

4.3 Pond Sand Filters (PSF):

Modified PSF are designed with capacity is for about 40 families i.e. about for 200 users. The estimated cost is about Tk 30000. The user contribution is 20% of the estimated cost.

Over the last decade, Bangladesh has emerged as a global reference point in experimenting with and implementing innovative approaches to rural sanitation. A national focus on sanitation carried out by the Government of Bangladesh at all levels likely helped to shift social norms around open defecation and sustain latrine use at large-scale. The Community-Led Total Sanitation (CLTS) approach was one such innovation that helped to move over 90 million people from open-defecation towards fixed-point defecation. Thus a steady paradigm shift occurred in sanitation sector as use of hygienic latrines instead of open defecation.

4.4 Twin-pit Sanitary System :

All over Bangladesh pit latrines are filling up, and the waste is being dumped unsystematically. Bangladesh has taken on second generation challenge in order to avert a probable environmental issue resulting from it. The most reasonable solution is reusing the pit content as organic fertilizer.

In consideration of the pecuniary condition of the common people, technological analysis, socio-economic spectra, water supply systems, maintenance of healthy environment and under the

perspectives of all other financial, social and physical infrastructure, twin-pit sanitary system is quite useful for Bangladesh. In this system, there are two shallow pits to contain wastes and water coming from the latrine. Only one pit is used at a time. When the pit becomes entirely filled with wastes, the second pit is then opened to be used. Construction of safety tanks in Bangladesh is not in tune with the financial capacities of common people. In twin-pit sewerage system, soil pipe connection is made from the latrine's pan to a specific connecting point. From that point, two branches of soil pipelines connect two waste containers.

5 Light Engineering industries

According to the Board of Investment data, the country has about 40,000 small-scale light engineering enterprises spread over the country and the industry manufactures about 10,000 types of items for the local industry. These small-scale formal and informal workshops have shown skill and innovative capacity to cater to the needs of accessories of various industries and households in the country. Bangladesh's light engineering sector has flourished from almost nothing to a multi-crore taka business since independence in 1971. The sector's development mainly came about at an informal cottage status. The industry is supplying demands of local textile mills, railways, jute mills, shoe manufacturers, sugar mills, RMG, washing plants etc. Import substitute machinery spares, plant machineries, small tools, toys, consumer items and paper products are made in the domestic market. The sector mainly involves three kinds of works -- making complete machinery, producing spare parts and repairing old machines. Bangladesh exports light engineering products worth over $300 million.

One light engineering company has its own innovation -- Bangla Car, a battery-run car with a capacity of 60 kilometers per hour. This rechargeable battery driven car consumes less energy and be completely environment friendly. As demand grows for engineering and electronic goods, so does demand for light engineering products.

5.1 Bicycle

Bicycle exports are the single largest product export within Bangladesh's engineering sector, contributing to about 7.5 percent of engineering exports. Exports began around 1995. Frame, fork, and wheel sets produced locally for the majority of bicycle models.

5.2 Shipbuilding

The main strengths of Bangladeshi shipbuilding are its long history of maritime activity, the presence of favorable geographical advantages, a low-cost shipbuilding workforce and industry-related educational and training institutes. It is one of the early industries developed in Bengal based on its old business of building boats and sea vessels. Due to this historic prosperous background and also a natural geographical advantage, there are presently more than 200 shipbuilding and ship-repair yards in Bangladesh. Today that Bangladesh was the center of building ocean-going vessels in Asia between the 15th and 17th century. Although it is not

possible to set up heavy industries overnight to make marine diesel engines, pumps, compressors, etc., there are many items like steel plates, pipes, valves, furniture, electrical cables, switchboards, transformers, motors, etc. that are made right now in the country. The country utilize the opportunity of shipbuilding as a foreign exchange earning source depends on manufacture the machineries, equipment and other accessories used on a ship. A private sector company, Western Marines Shipyard Ltd., is building Heavy Ocean going vessels and exporting them to Denmark and other countries.

6 Infrastructure

6.1 RCBM (Reinforced Concrete Block Masonry)

Environment friendly Concrete Blocks are in place of burnt clay bricks. Since 1999 the use of RCBM (Reinforced Concrete Block Masonry) method in construction of high-rise Building with load bearing concrete blocks had used. Research shows that this method is more earthquake resistant and structurally sound for infrastructure.

6.2 Low-cost Sustainable Model Houses

Housing is an outstanding basic need of mankind. The poverty stricken common people of Bangladesh build their homes by forest-grown building materials like bamboo, wood, straw, jute-stalks, jute-ropes, etc. Such houses are never sustainable. They just crumble down by cyclones or similar other natural calamities. But with the increase in population, people are confronted with utter difficulties in procuring building materials, in building houses and maintenance. Research & Development Unit of LGED has evolved three types of newly designed model houses for poor people. In these houses, very limited quantity of rod, cement, brick and sand are used. As a result, these houses are quite economic, but long-lasting and strong.

6.3 Inter-Locking Bricks

Bricks, generally, are of uniform size and measure. Such bricks when used in the construction of roads are liable to be removed easily. Moreover, the capacity to bear loads by these bricks is lesser and as such those have limitations when used in constructing roads. Interlocking bricks are made of cement and brick-chips mixed together and they are of different geometric shapes. These bricks are much larger in size in comparison to normal bricks. So, the number of joints tends to be lesser in construction works with these bricks. Interlocking bricks, produced on trial basis have been used in constructing internal roads in rural markets.

6.4 Low-Cost Concrete Road Roller

Compaction of soil is very important for rural road construction. LGED constructed low-cost concrete road rollers with their own technical know-how. Construction of a concrete roller,

weighing 6 to 8 tons, costs Taka 35 thousand to Taka 45 thousand only. A layer of soil measuring 9 inches in thickness, if undergoes compaction for 16 times by this roller, comes down to 6 inches. In the process, soil gets compaction up to 98%. Besides, this roller is being used in the compaction of bituminous carpeting. Low-cost LGED concrete Road Rollers have been proved cost-effective and facilitating its easy application in stabilizing and strengthening the country's extensive rural infrastructures. The technology of carrying rollers quickly to work sites by the trailer has been developed by LGED in Comilla.

6.5 Fibre Concrete Roof-Tiles

Various companies and NGOs are currently marketing clay tiles, PVC tiles, ferro-cement tiles as alternatives to CI roofs. These roofing materials are being hindered to be popular because of their costs and sustainability. The trial production of fibre concrete roof tiles and its uses were implemented in Faridpur district as a part of appropriate and cost reducing technology development under Rural Development Project. In this technology, jute is used as the fibre. Production under this technology is feasible fully by providing training to ordinary laborers. Fibre concrete roof-tiles are considered to be quite effective in the construction of shades at rural markets and bazaars.

6.6 Cold-Drawn Wire Prestressed Concrete (CWPC)

Efforts are going on for **Eco-Housing**, to give a relief pressure on energy sector (electricity, fuel, and other resources) and environment friendly housing of Bangladesh. The cold-drawn low-carbon steel wire used for prestressing is made of ordinary hot-rolled carbon steel coil rod. This is processed at room temperature through a special wire drawing die. The low-carbon coil rods are manufactured by the steel mill; the wires are processed at the prefabrication plant. By cold-drawing the low carbon coil rod into wires, the strength is enhanced about twice as much as that of the coil rod. CWPC technology is suitable for producing small and medium size members, such as beams, slabs, roof trusses, window and door frames. CWPC members can cause savings up to 30-50% steel consumptions and can reduce about 10% the cost of construction

6.7 Community Participation in Infrastructure Development

Infrastructure development activities of LGED are planned and implemented through community participation process. Implementation of project activities is done with involvement of the private sector. Small and medium contractors take part in construction activities of LGED. In addition, the Local Government Institutions (LGIs) at various levels are also involved in the implementation of LGED project. Moreover, NGOs are involved to assist LGED in social mobilization aspects for planning and implementation of schemes. As a part of participatory development, beneficiary groups and user committees, such as, Labor Contracting Society (LCS), Market Management Committee (MMC), Ghat Management Committee (GMC), Road User's Committee (RUC), Water Management Cooperative Association (WMCA) etc. have been formed under various projects of LGED. Involvement of the private sector, Local Government

Institutions, NGO and beneficiary groups have significantly contributed to smooth planning, implementation and operation/ maintenance of infrastructure development schemes of LGED at the local level.

7 Disaster resistance construction technology

Bangladesh is a disaster-prone country due to its hydrological and geo-morphological realities. Given the evolving climate change, the country has begun to be visited by extreme climatic events more frequently. According to Climate Change Vulnerability Index (CCVI) Report 2011 that Bangladesh is among the 30 most vulnerable countries to climate change, out of 193 nations. The Sustainable Environment Management Programme (SEMP), Coastal and Wetland Biodiversity Project (CWBMP) and Nishorgo Project of the government have helped bring in innovative approaches of community management of coastal and wetland ECAs and their biodiversity including fishes, birds, animals and indigenous trees as well as established forest sanctuaries for wildlife. These projects created incentives for communities for the protection of biodiversity and alternative sources of income for them. It has also helped the communities to seek protection from tidal surges and floods by building barriers with indigenous water resistant trees. To provide protection against tidal surges during cyclones, mangrove plantation was undertaken on 160,000 hectares of newly accreted coastal land in the recent years. The Coastal Green Belt project continues to implement the coastal afforestation initiative of the government.

7.1 Raised platform houses

The obvious measure which may be adopted for flood-prone areas is to raise the floor level above the level of flood-water. Efforts made on raising of private individual and clustered homesteads 60 cm above the highest recorded flood water line on earthen plinths. Soil from the adjoining area is lifted and laid by hired labor, then compacted by the recipient families. The plinth's slopes are planted with fodder grasses to protect them, while providing a supply of feed for livestock. There is sufficient room on the plinths for livestock and to plant a small garden and fruit trees.

7.2 Green embankments

Periodic and seasonal Floods often damage roads, dyes and embankments that are important links in rural areas. "Sustainable Dyke Repairing" projects are taken by water Development Board. The embankment construction and repairing by using Green Soil Bag has successfully done in some places. Along the slope of the embankment some soil bags are placed. These bags are strong enough to protect the level of tidal surge. Bags help the soil to be compacted. It is the combination of biotic grass seeds and biotic elements (jute bag, soil). A bag is filled with the mixture of seed of grass and soil, and then it is placed on the embankment. Grass sprouts up within two weeks through the tiny hole of the bags and their roots enter into the deep of the soil.

7.3 Bamboo Plantation

Bamboo is a very fast-growing wonderful natural resource suitable for climate change adaptation by converting atmospheric CO_2 into biomass, keeping water table up, controlling erosion, acting as strong windbreaks and reducing storms and cyclones. It rejuvenates and creates soil and it has endless uses. More interestingly, it grows luxuriantly without application of chemical fertilizers and pesticides and it absolutely grows organically. Bamboo is a cheap and easy available building material in rural areas.

People have learned to prevent losses by using viable methods that have been practiced for generations. Certain traditional techniques can help rivers and channels from getting silted and prevent excessive run offs during heavy rains. Planting bamboo helps to protect the bunds from being breached and prevent rapid run off from the river channel when the river overflows during heavy rainy days. Even planting bamboo along fish ponds and paddy fields prevents soil erosion and stops water from submerging low areas during peak flooding days.

7.4 Mud blocks

The mud blocks are also using in rural areas. Blocks were manufactured on-site block making machine, partly using recycled materials from the dismantle houses. The upper floor and roof were then constructed using a bamboo frame which is treated to improve durability. Sometimes bamboo staircase and balcony are attached with these houses. Roof tiles are also innovative. These cement tiles are created using fine stone chips and cement (ratio 3:1) and is combined with sufficient water to produce a tight mixture. It is then transferred to a flat mould, where air bubbles are removed through vibration. This is achieved using a bicycle-powered machine.

7.5 Early warning systems

Early warning systems can thus save thousands of lives - and don't necessarily need to be expensive high-tech solutions. In Bangladesh, the deaths of 300,000 people in 1970 led to the establishment of a network of Red Crescent-trained volunteers who cycled around the country warning residents of the arrival of a cyclone. Thanks to their efforts, just 3,500 people died when Cyclone Sidr hit land in November 2007. Two million Bangladeshis were protected within 1,800 cyclone shelters and 440 flood shelters. In stark contrast, Cyclone Nargis resulted in at least 130,000 fatali. Bangladesh has pioneered cyclone response mechanisms in terms of cyclone shelters and volunteers to assist people to evacuate to the shelters when a cyclone is impending and help them with accessing immediate relief services. Also, community-based disaster risk aversion and impact management approaches and activities have been developed.

8 Conclusion

Certainly, the present government is promoting innovation in a knowledge-based society to achieve “Vision-2021”. Creative citizens will be the driver of Bangladesh’s journey to middle income and high HDI country status by 2021. The knowledge and expertise gained through practice is developing innovations thereby leading to the development or upgrading of

technologies. Still Bangladesh is not a powerful nation in terms of global innovation index. Public policies need to support in linking the academy, companies, and governments. Finally, it is particularly important to generate innovative environments. It is also essential that the government become involved as a catalyst for interaction among stakeholders, particularly in regard to the mechanisms that lead to a closer relationship between academia and businesses, the promotion of the best intellectual property management practices at universities and technical institutes, and actions that promote an increase in the number of patents.