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Bangladesh: Increasing Rural Farm-to-Market Capabilities through the Development of Infrastructure and Technologies

Introduction

A country roughly the size of New York State, Bangladesh is home to more than 150 million people. Situated on the delta of the two largest rivers (Ganges and Jamuna) on the Indian Subcontinent, Bangladesh is one of the world's most disaster-prone regions, affected by a myriad of natural disasters including cyclones, floods, and drought. Because two-thirds of its territory is less than five meters above sea level, it is one of the countries most vulnerable to floods (Rath). The combination of all these factors exacerbates an already desperately severe poverty and malnutrition problem. In fact, Bangladesh is ranked near the bottom at 129th out of 169 countries in the 2010 Human Development Index and 68th out of 79 countries in the 2012 Global Hunger Index ("Bangladesh: Country Resources"). Sadly, over 40% of the population in Bangladesh lives below the designated food poverty line, with 28 million in the "ultra-poor" category. These individuals consume less than 1,800 calories a day, lacking adequate food and productive assets necessary for providing their sustenance ("Food Security Atlas for Bangladesh").

Poverty in Bangladesh is most highly concentrated in rural areas, where more than 80% of Bangladesh's population resides ("Bangladesh: Country Resources"). These rural communities have a 36% poverty rate compared to 28% in urban centers. According to a report by the International Fund for Agricultural Development, 43.2% of all rural children under the age of five face chronic malnourishment and stunted growth, while 14% suffer from acute malnutrition and stunted growth. Poverty is especially persistent in three areas: the north-west, affected by droughts and river erosion; the central northern region, plagued by seasonal flooding; and the southern coastal zones, which are affected by soil salinity and cyclones (Rath). The majority of the rural poor consists of subsistence farmers in a country where agriculture employs 44% of the labor force (Rath). Because the population is growing at an alarming rate, the urbanization process rapidly shrinks the available amount of farmland, further decreasing the already minute amount of land that rural households can cultivate. With more than 160 million people, Bangladesh is ranked as the eighth most populous country in the world (UNDESA). Moreover, the population of Bangladesh increases at a rate of 1.59%, adding approximately 3 million people per year ("Population Growth Rate"). As the population grows at this incredible rate, the level of food insecurity will continue to worsen if actions are not taken to combat this problem. Despite the critical situation that Bangladesh currently faces, it has great potential to become a self-sustaining nation through the development and implementation of infrastructure and technologies in rural areas.

The Structure of a Subsistence Family

The typical rural Bangladeshi family is heavily centered on family and kinship. The most basic social unit of a village is the family—called *paribar* or *gushi*, and normally consists of a complete or partial patrilineally extended household residing in a homestead, or *bari*. In rural society, the effective household (or *chula*) is defined as an extended family that exploits jointly held property and jointly operated kitchens (Heitzman and Worden). As of 2005, the average rural household size is 4.89. Among rural families, rice is by far the most prevalent food, composing 80% of the daily food intake. Though extremely important to nutrition, vegetables and other necessary foods are seldom consumed by rural households, both because of poverty and because of lack of knowledge (Chowdhury). Furthermore, the abject poverty means that rural households do not consider that educating children is a high priority. As a result, primary education, if any, is the extent of most rural families. An estimated 3.3 million children

remain unschooled, and only 51% of those in school will complete primary education ("Bangladesh: Overview"). The low rate of education has a particularly strong impact on girls from poor families. Rural families affected by natural disasters develop detrimental coping strategies, including withdrawing children from school and selling productive assets. Thus, education levels are a strong indication of a family's economic situation. Children of mothers who have no education are more than twice as likely to have stunted growth than as children raised by mothers who have completed secondary education or higher. The combination of poverty, malnutrition, and lack of education creates a vicious cycle that entraps many rural households.

Yet another devastating issue lies in the unreliability and the shortage of healthcare for rural families. Those living in rural villages often have difficulty receiving medical care due to the lack of access/monetary resources and the lack of medical facilities available ("Access to Healthcare in Bangladesh"). Village "doctors" with little or no formal training constitute 62% of healthcare providers. Shockingly, only a mere 4% of the healthcare workforce has received formal training. Despite the low levels of formal training of village doctors, nearly 70% of the patients receive curative services through these doctors (Bhuiya). Considering the quality and access to healthcare, it is not surprising that health problems abound among rural Bangladeshis. In 2009 alone, tuberculosis was detected in 425 per 100,000 individuals ("Global Health Observatory Data Repository"). Particularly worrying is the effect of poor water quality on the health of these people. Bacteria contamination of surface water leads to the common observance of malaria, leptospirosis, and dengue. Additionally, arsenic poisoning of Bangladesh groundwater slowly destructs the health of many Bangladeshis (Nickson et al.).

In Bangladesh, much of the land is fertile. In fact, 62% of the total land is arable ("Agricultural Land"). However, because of the rapidly increasing erosion and construction to accommodate the population growth, the amount of land available for agriculture is steadily decreasing; increased urbanization has caused the cultivated area of land to decrease at a rate of 1% per year ("Bangladesh: Country Resources"). Despite the seemingly great amount of land available, subsistence farmers often have very small plots of land. In fact, the average size of operational holdings is only 0.5 hectares (Uddin and Halim). The main reason behind the disparity of the amount of land available and actual per-person plot is uneven land distribution. In 1994, the bottom 40% of households collectively owned less than 2% of the total land, and the top 5% owned nearly 35% (Rath). This vast disparity leaves the rural farmers with small, fragmented farms that have little productive potential. On the land available, rural farmers typically grow rice and wheat, with 79.4% of the total cultivatable land under rice crop. Three separate rice crops are recognized each year: the rain-fed *Aus* planted in March/April, the rain-fed *Aman* planted in July/August, and the irrigated *Boro* planted in December/January ("Agricultural Production"). The typically low-yielding *Aus* crop is mainly cultivated in isolated pockets of the west and the south during the summer. The monsoon-fed *Aman* crop is the most widespread, and is also cultivated in the coastal areas. Finally, the *Boro* crop is cultivated in most regions, except for the saline soil coastal zone. Because the *Boro* crop is irrigated, it is less affected by adverse weather conditions. However, irrigation of *Boro* crop drops the water table in certain areas by 4 to 5 feet per year. Thus, the Government of Bangladesh is more focused on the expansion of *Aus* production (Hussain). Wheat is the second most important crop in terms of area cultivated. It is grown mainly in the drier, northern parts of the country, and is cultivated only as a winter crop. The most important export crop of Bangladesh is jute, which is ranked third in terms of cultivated area and is grown mainly in the lower-altitude regions of Brahmaputra-Jamuna and the Padma floodplains. The fibrous jute is manufactured into useful goods such as carpets, bags, and ropes. Other important crops include mustard, *masur* (lentil), and *khesari* (chickling vetch) (Ahmad and Ahmad).

Bangladesh is faced with a rather intriguing situation—there are relatively fertile plots of land, yet production levels are not high enough to support its own citizens. Because of this, many Bangladeshis are dependent on foreign aid for food, especially in times of flooding and crop destruction. However, no

amount of foreign aid is enough to completely alleviate hunger and poverty issues because foreign aid (especially food aid) is only temporary. In order to eradicate poverty and hunger for the long term, the problems of agricultural productivity need to be systematically addressed. There are several factors of varying severity that contribute to the low agricultural productivity in Bangladesh. Firstly, the physical size of most farms limits the amount of output possible. As the average rural land holding is 0.5 hectares, the physical constraints prevent rural farmers from improving agricultural output. Additionally, small fragmented farms have little access to credit, machinery, and other necessary instruments. The land situation in Bangladesh is progressively worsening. As mentioned before, the amount of arable land available is being diminished by various factors, including urbanization and erosion. Secondly, rural farmers are slowly stripping the land of its nutrients. Continual planting of rice without crop rotation depletes the same set of nutrients each year, decreasing the productivity of the land. Thirdly, nearly 50% of Bangladesh's area remains inundated from June to October. Along with this excess water come waterborne diseases from surface water pollution. During this time period, only crops tolerant to waterlogging can be grown in these areas (Ahmad and Ahmad).

Furthermore, an important barrier is the lack of infrastructure and farm-to-market access afforded to the rural farmers. Even if Bangladeshis manage to increase agricultural productivity, they will not benefit fully without well-functioning roads and market information access. The surplus of food would spoil in badly maintained (or non-existent) storage facilities, leaving rural farmers without profit. Aside from agricultural impacts, poor infrastructure also has major implications for rural education. Because smallholders (farmers with less than 50 acres) are isolated from schools, it is extremely difficult for children to be educated. Thus, it is critical that the rural poor are given access to markets in order to improve living standards and education levels.

A farmer from Juncal, Ecuador astutely noted, "A community without roads does not have a way out." This statement describes many rural Bangladeshi communities as well as many other isolated communities around the world. The underlying principle is simple: without proper access to markets and the outside world, poor groups will stay poor, and the disadvantaged will stay disadvantaged. A young woman in Little Bay, Jamaica said, "If we get the road, we would get everything else, community center, employment, post office, water, telephones." (Cook). Market access, road development, and other communication technologies are invaluable for rural mobility.

Currently, the terms upon which the rural poor enter into markets are inequitable. Many poor are currently "passive participants, often obliged to sell low (immediately after harvest) and buy high, with little choice of where they conduct transactions, with whom, and at what price." ("Markets for the Rural Poor"). In settings with poor road quality, traders are essential "lifelines" to the rural farmers. These traders travel to remote locations to buy and sell produce. Specifically in flood-affected regions, traders may arrive unreliably, if at all. Because these traders may have monopoly of power, rural farmers are pressured to accept the first offer provided, regardless how unfavorable the offer might be. In Bangladesh, rural producers also often lack access to information regarding market dynamics. Information is as important as the seed and the plow when it comes to production and marketing of goods. Additionally, rural producers are constrained by the lack of business and negotiating experience that would help them interact on equal terms with market intermediaries. The inability to competitively market produce leads to a diminished income for production inputs and prevents asset accumulation. Hence, with insufficient roads, rural Bangladeshis are cut off from emerging markets and technological developments (Jazaïry et al.). Poor infrastructure hinders communication, both with markets and society, causing increased isolation.

Infrastructure's current role in Bangladesh

The current farm-to-market access in Bangladesh is dismal. Many infrastructural bottlenecks, both physical and virtual, constrain access to markets. The first barrier is the number and reliability of roads. The current infrastructure does not meet the demand, considering the number of rural farmers that need the functionality and access that these roads should provide. A good measure of the quantity of roads is the road density. According to the World Bank, the road density (in km of road per 100 sq. km area) in 2003 was 166 km/100 km². After a devastating flood in 2004 during which two-thirds of the country was under water, the road network took an extremely large hit. Because only 30% of all roads were paved, the effects of the flood were especially devastating (“Bangladesh - Highway Data”). The resulting road density in 2005 was 14 km/100 km²—a 92% drop from that of two years ago (“Road Density”). From 2005 to 2012, the road density has only shown a slight increase from 14 to 15 km/100km². These numbers highlight the magnitude of the current infrastructure crisis and the vulnerability of the existing roads. Keeping in mind that these numbers are calculated from an average of all the roads in Bangladesh (including urban areas), the condition of the rural road network is therefore much worse.

Looking with a more focused lens upon the rural road situation, only 37% of the population lives within 2 km of an all-season road. Most of the union roads remain unpaved, and thus impassable during rainy seasons. The conditions of rural roads remain far from satisfactory because “the quality, construction, and tertiary road network remains poor.” (“Investing in Rural Roads”).

Lack of infrastructure contributes to a major gender disparity in Bangladesh, limiting women from developing key skills, and ultimately impeding smallholders. Because rural women traditionally do not labor outside the house, they have little opportunity to develop outside experience. This problem is exacerbated by the lack of infrastructure because without access to outside communities, rural women cannot take employment opportunities. Unless substantial investments in road networks are made, Bangladesh will continue to have low mobility of citizens and high rural transportation costs.

Aside from road development for market access, a second major form of infrastructure development is greatly needed: electricity generation and distribution. Nearly 70% of rural population does not have access to electricity, although rural farmers account for 85% of the total population in the country (Grameen). Even for those that have access to electricity, the supply is still very unreliable because governmentally owned plants are often older than 25 years and are poorly maintained (Sovacool and Drupady). Electricity is the “key which opens the door into the modern world. Without it, communities and individuals are denied access to a high proportion of the benefits and amenities which people ... take completely for granted” (“Electricity for Rural People”). For most rural Bangladeshi farmers, life comes to a standstill after sunset. Without electricity, completing even the most basic tasks require great strength and ingenuity. In order to increase agricultural productivity on rural farms, useful tools and machines must be powered by a steady supply of energy. There has been some efforts to increase electricity access; however, there is still great demand for electricity in rural areas.

In addition to physically enabling rural farmers through road and electricity access, the third major element needed in Bangladesh is a strong information communication infrastructure. Isolated and uninformed farmers cannot participate effectively in commercial exchanges. Without mobile or wireless communication with markets, input and output prices are practically inaccessible. As a result, rural farmers cannot plan ahead and take advantage of surplus, even if markets are available. In recent years, Information and Communication Technologies (ICT) development has been increasing, with mobile phones growing the most rapidly in comparison to other forms such as computer systems and e-mail. As of 2010, the percentage of rural households that used mobile phones was 56.77% compared to 0.97% and 0.39% for computers and e-mail systems, respectively (Rahman et al.). The current usage of ICT is primarily for socialization and entertainment reasons, rather than for business applications (Rahman et

al.). 44.2% of Bangladeshis under 18 use mobile phones to spend time in entertainment. For ages 18-30, 31-40, and >40, the primary use is socializing, averaging at 38.6%, 65.2%, and 50.6%, respectively. Clearly, the use of mobile technology and ICT in rural Bangladesh is not being used to its full potential. There have been some efforts to further develop ICT in recent years; however, Bangladesh has less than 700 ICT enterprises, and only 0.1% of its businesses are focused in the ICT sector (“Bangladesh’s ICT Sector”). In Bangladesh, bad road quality and quantity, frequent power outages, and inadequate technological utilization are all compounded to work against rural farmers. In order to develop a substantial and lasting solution to the farm-to-market issue, all three of these infrastructure sectors need to be improved.

Benefits of Infrastructure Development

Once infrastructure improvement is implemented, the benefits will be innumerable. Specifically within the realm of road improvement, the first and most obvious result is increased physical access to markets. By lowering the high transportation costs and time, farmers can immediately and directly increase their profits. The issue of rotting surplus also becomes less severe because produce spends less time between farmer and market. Increasing farm-to-market access through development of secondary and tertiary road density will create a more dependable source of income for smallholders.

As a result of road development, many additional spillover benefits will be observed. Rural children will be able to access schools through safer and faster routes. In addition, teachers will be more willing to station themselves in schools with safe and effective roads. Education will have long-term effects as educated rural Bangladeshis either inherit family property or seek more productive jobs. Through the roads, farmers will also gain access to more efficient seeds, and modern farming machines and techniques. These technologies will allow farmers to increase agricultural yield greatly. In the more long-term view, farmers will be able to shift out of pure subsistence farming and begin to grow in response to the market demands. The growing of different crops also opens up the possibility of crop rotation. If farmers are able to practice crop rotation effectively, the nutrient integrity of the land will be maintained while simultaneously increasing yield. If access to a variety of seeds is accomplished on a widespread scale, the practice of crop rotation can largely benefit the environment and the richness of the soil.

Rural women, currently the most disadvantaged group, will also experience tremendous benefits from road development. The most crucial step to empowering rural women is to provide them with the needed skillsets to support themselves and their families. Along with new roads will come employment opportunities and exposure to the non-agricultural world. Through work experience and learning, women will be able to develop key skills and, over time, change the societal expectations for rural women. This change will not occur immediately but will be a gradual process involving changes in perception and redelegation of roles.

Rural smallholders will also benefit greatly from a steady supply of electricity. For example, rural electricity can power refrigeration systems that help keep food supplies safe in storage. The critical ability to maintain food supplies will create new opportunities for the production and shipment of perishable goods (Campbell). Farmers will no longer be pressured to sell at the first bid, but will be able to sell and buy in response to changes in the market. Electricity also has the potential to mechanize many tasks that are traditionally done by hand. One such task that can be greatly simplified is drawing water. Electrically powered water pumps can eliminate the need to carry buckets from wells or from streams. There are also major implications for smallholders who raise livestock and poultry. Electrically powered incubators and milking machines greatly increase efficiency in farms. With farm work significantly reduced, rural Bangladeshis will be able to invest their time more wisely for more productive activities.

Development of strong ICT can also benefit the rural poor in many ways. Because mobile telecommunication networks are one of the most rapidly developing technologies in the 21st century, they provide the opportunity to “transform the developing economy markets into more competitive and efficient markets” (Zainudeen et al.). New e-commerce systems have the potential to reduce transaction costs and increase revenues for traders. These systems can also reduce friction and expand markets by allowing larger volumes of transactions to take place (Mann et al.). Rural farmers can also take advantage of wireless systems and access to internet to be able to communicate with markets more efficiently. The ability to disseminate information will increase mobility around the village. The presence of phones in villages makes the information about input and output prices readily accessible. Additionally, women will be empowered through mobile access. Currently, rural Bangladeshi women are deprived of access to information and are dependent on the social system of superstitions and traditional belief systems (“D.Net: Pallitathya Help Line”) It has been empirically demonstrated that owning a phone increases prestige and respect within the village (“Market for the Rural Poor”).

Another major benefit of mobile and wireless communication is improvement of health care. Instead of solely relying on non-professionally trained “village doctors”, rural farmers will have better access to health professionals. Emergency and police vehicles will also have faster transportation times because of the developed phone and road systems. Grameenphone, the leading telecommunications service provider in Bangladesh, along with its healthcare service has shown how all of Bangladesh can be provided with primary healthcare through inexpensive phone calls. ICT development, especially mobile phone technologies, makes medical care more accessible through fast communication and over-the-phone support (Rahman et al.). ICT can also have the potential to preserve livestock health, as owners can send and receive warnings of outbreaks and disease.

Influence of other Factors

In Bangladesh, development of better farm-to-market access is and will continue to be affected by various other factors. The most important and pressing influence is the severe flooding and erosion of land. Excessive rains and sea level rise during the rainy season cause floods, while insufficient water during the dry season causes drought (Islam). Because of extreme flooding and other natural disasters during the rainy season, simple dirt roads will not be enough. To protect the road network from another disaster like the 2004 flood, the roads developed need to be submersible and tolerant to various forms of weathering. This will help ensure their sustained impact.

To take an example, these highly resistant roads have been successfully used in Barry County, Missouri. Historically, the Big Bass Bend road in Barry County also faced a similar flooding problem. Heavy rains washed away parts of the road, leaving people without access to their homes and aggravating poverty and financial burdens. However, in 2008, the Federal Emergency Management Agency made efforts to fortify the road, including raising and strengthening the roads. In 2011, after over 2 months of being submerged under 6 feet 6 inches of water, the road was still intact and functional (“Country Road”). Effective measures applicable to roads in Bangladesh include development of culverts, low-water crossings, and bridges. All three of these enhancements allow flood water to pass more freely under the roads, therefore reducing the potential stress and damage (“Flood-Resistant Local Road”). Despite higher upfront cost, such investments are economically feasible in the long-run, as disaster-resistant roads reduce the cost of annual maintenance and repair.

As a result of climate change, floods have been increasing in intensity and frequency over the past few years. Along with floods, cyclones also cause damage and death every year to infrastructure and livestock. Furthermore, despite the extreme flooding during rainy season, there is a lack of water during the dry season. This decrease of water flow invites salinity inland, decreasing agricultural productivity of

the land (Rahman et al. 1994). Increasing demand arising from rapid population growth has also strained availability of water resources.

In terms of ICT development, international trade plays an instrumental role. Globalization of trade as a whole will help expose the country to private organizations and attract other potential investors. In Costa Rica, such development of international trade helped attract Intel to invest in the local economy. The presence of Intel in Costa Rica has driven development of road, education, and local electronic and construction industries, generating over 2,800 jobs (“Intel in Costa Rica”). In the same way, the globalization of trade in Bangladesh will draw in other investors to take similar developmental steps. This creates a cycle in which globalization becomes increasingly important for ICT implementation, and technology also becomes necessary for globalization. As globalization and competitiveness rely more and more on effective participation in the technological market, it becomes increasingly difficult for developing countries to enter (Dahlman). Thus, globalization both relies heavily on and necessitates the development of ICT in Bangladesh.

Because population growth adds nearly three million people a year, there has been increased urbanization. Rapid urbanization in Bangladesh develops several serious problems. The incredible population density deteriorates the overall housing, sanitation, water, energy, waste disposal, and living conditions (Ahmed). Powered by the population growth, energy demand is increasing. The reliable electricity generation capacity averages around 4,300 Megawatts (MW), while the peak demand exceeds 5,000 MW on most days (“Bangladesh: Meeting Energy Demand”). The high demand leaves users without energy in the most important hours of the day. Because the sector is financially weak and costs remain high, it is increasingly difficult to meet growing demand for electricity. Thus, rural smallholders must turn to alternative, off-grid solutions in order to obtain a more stable supply of electricity for farm-to-market access.

Urbanization and population growth also drive many other problems in Bangladesh. Industrialization massively pollutes land, air, and water. Smoke from industry, hazardous chemicals and toxic materials, and industrial wastes all pollute both surface and ground water. Thus, pollution has become an increasingly significant factor in Bangladesh (Rahman and Ziaur). The expansion of human settlement to accommodate the huge population has now encroached upon the forested regions of the country. Because of general land shortage, agricultural land continues to be lost to the expansion of urban settlements. All these factors work together and impact rural farmers either directly or indirectly. Many of these factors severely affect rural women specifically. Rural women collect food, fodder and fuel from trees and forests. When supplies shrink, women are affected disproportionately by less food and harder work (Jahan). Because women are considered principal resource managers, they are expected to “achieve miracles against all odds” (Haider). As water quality and quantity continue to degrade, the time spent by women in providing water is quite considerable. Women are required to walk farther and farther to collect water for daily use. Even the water that rural women manage to collect is not entirely safe because of arsenic pollution in multiple districts. (“The Advancement of Women in Bangladesh”). Overall, factors such as rapid urbanization, land erosion, water scarcity, and climate change hinder those with scarce resources.

Recommendations and the Role of Communities and Various Organizations

In order to reduce hunger and poverty by 2015, rural infrastructure needs to be developed through the efforts of multiple agents. Once proper infrastructure is achieved, traditionally isolated smallholders will benefit from physical farm-to-market access, and will find many other uses for developed roads, electricity, and information communication systems. Various small scale efforts have already been made to achieve Millennium Development Goals. One such project, entitled Market Infrastructure Development Project in Charland Regions (MIDPCR), sponsored by the World Bank, has aimed to empower rural women and eradicate extreme poverty. Beginning in 2006, MIDPCR has been working jointly with the

government of Bangladesh as well as Infrastructure Development in Bangladesh (IFAD). Investing a total of USD 43.9 million, MIDPCR employs poor primary producers, small traders, and women laborers to construct road and market infrastructure (Hessel). Hence, MIDPCR created employment opportunities for many people, even offering training and access to financial services to support income generating activities.

Over a period of seven years, 432 km of road and 66 markets were constructed under MIDPCR. Surveys conducted in the project area show the impacts on the life of rural people. Travel costs have decreased by 8% on market days and 38% on non-market days. Travel time has decreased, as the average speed of motorized vehicles has increased by 136% during dry season and 182% during monsoon season. 95% of rural people stated that access to health care has improved and 87% answered that access to markets has strongly improved and access to good and services have become affordable. 87% also reported that school access has become better and that better teachers are willing to be stationed in rural areas with improved infrastructure. In the project areas, girl's enrollment in primary education has more than tripled and overall enrollment in primary education has nearly doubled from 2006 to 2013. 70% reported an increase in their food security while 75% indicated an increase in income. Land value has also increased, by anything from 7% to 900% (Hessel).

To construct roads, MIDPCR took a unique approach and worked with Labor Contracting Societies (LCS). LCS are groups of women who, after receiving training, construct roads, market infrastructure, and boat landing stages. Because rural women traditionally do not have the opportunity to work outside of the household, this project provided a rare opportunity for them to learn essential skills and earn money. The women in LCS not only received money from their wages but were also given a portion of the profit made during construction. With the money earned through LCS, the women were able to start development paths with long-lasting impacts. More importantly, the work and money earned through such projects strengthened self-confidence and position in the community. One woman from LCS decided to run in the Union Parishad Election and won with a large majority. Overall, 50% of rural people stated that mobility of women has increased. This fits in with the third Millennium Development Goal: promoting gender equality and empowering women ("After the Harvest Is In").

Following the successful model of MIDPCR and IFAD, Bangladesh can scale up infrastructure development to encompass more rural areas. As evidenced by the development in Charland regions, infrastructure development will play an incredible role in reducing poverty, hunger, and isolation. Large scale implementation also must work in conjunction with LCS or otherwise empower women in order to have long lasting impacts. Infrastructure development would substantially increase farm-to-market access and provide rural people with employment and new skillsets.

Another infrastructure development project regards rural access to electricity. Bangladesh has been considering two different electrification schemes. The first aims to extend and to intensify the central grid, while the second is to deploy off-grid technologies (Rahman et al. 2013). Because of the dispersed nature of rural settlement and the many rivers that traverse the country, traditional grid electrification is both difficult and expensive to implement. Many rural areas are not connected to the grid, so solar power is the most viable and sustainable way to provide energy. The Rural Electrification and Renewable Energy Development Project (RERED) took both methods to heart and supported rural electrification primarily through off-grid options, and using grid options whenever possible. Specifically, the project made Solar Home System (SHS) available to households through nongovernmental organization (NGOs) and microcredit schemes ("Bangladesh: Lighting up Rural Communities").

NGOs procured and installed SHS in rural households according to the Infrastructure Development Company Limited (IDCOL) technical standards. The rural households paid a 10% down payment and

fulfilled the remaining 90% in smaller installments over the period of three to five years. Various partner organizations (POs) then applied for refinancing from IDCOL. Refinancing provided POs with funds to install more and more systems (“Bangladesh: Lighting up Rural Communities”). The World Bank has also made subsidy amounts available, from both the Global Environment Facility (GEF) and the Global Partnership on Output-Based Aid (GPOBA). Every month, 50,000 solar homes are installed, changing people’s lives and allowing children to study and businesses to stay open at night. The use of solar energy to power rural households fits in snugly with the seventh Millennium Development Goal: ensuring environmental sustainability. The innovative use of SHS provides both electricity to rural households and a sustainable future for Bangladesh. Although the project has increased access to electricity in Bangladesh by 3.5%, SHS need to be implemented on a much larger scale in order to benefit many more rural households.

In order to make a substantial impact, many players will need to have a role in infrastructure development. One entity to take up such a role is the government of Bangladesh (GOB). Farmers will heavily rely on the government to improve rural marketing infrastructure, improve roads, provide marketing information, and promote economically viable investment. The most important role of the government is to ensure a “clear and stable policy and macro-economic environment” in which the private sector is able to rapidly respond to opportunities (“After the Harvest Is In”). To meet the challenges, the GOB will need to undertake reforms to make financing available to unserved rural areas. Private management and capital can also substantially expand coverage and quality of infrastructure services in Bangladesh (“Private Solutions”).

As of now, private sector’s interest in road development has been limited. However, so-called operate-and-maintain (O&M) road projects offer opportunities for private sector participation. The GOB will build road or bridges with its own resources and then enter into an arrangement with a private, outside party to operate and maintain the facility (“Private Solutions”). Investment in rural infrastructure also has major implications for the investors themselves. According to the World Bank and Public-Private Infrastructure Advisory Facility, there is probably no higher rate of return in roads than that of investment in rural road maintenance. In addition to the coordination of international, governmental, and private institutions, incorporation of the rural community in development is essential. As MIDPCR demonstrated, programs which incorporate Labor Contracting Societies can have a direct and immediate benefit to the rural poor.

In the context of developing SHS and improving access to electricity, microfinancing is necessary to ensure sufficient implementation. As economist Adam Smith said, “Money, says the proverb, makes money. When you have got a little, it is often easy to get more. The great difficulty is to get that little” (“The Wealth of Nations”). Smith aptly describes the situation of many rural Bangladeshis. If the GOB, microfinance institutions, donor agencies, and most importantly, rural farmers band together, then the financing of solar energy development will become more feasible. In addition to microfinancing, privatization and liberalization will help drive funding for development. Integration Independent Power Producers (IPP’s) have been shown to increase efficiency and improve reliability. Such privatization is necessary in Bangladesh for two reasons: (1) inefficiencies in state-owned utilities and (2) persistent and costly supply shortages. The GOB has recognized this issue, and enabled private investment in the power sector to address constraints in capacity expansion (Helal).

Much in the same way as rural electrification should be implemented, ICT development should also incorporate public and private financing. Although Bangladesh was one of the first Asian nations to allow private participation in the telecommunications sector, the pace of reforms has been slow, and Bangladesh has fallen behind in terms of performance (“Private Solutions”). At present, there are two fixed-line operators that provide only 26,000 rural mainlines. High rural connection charges exacerbate the limited

access to telecommunication services. In India, Public Call Offices (PCOs) were introduced to mitigate similar problems. The successful use of PCOs has provided citizens with affordable access to telecommunications. The governments of other countries have also devised innovative solutions to developing telecommunications. Chile, Columbia, the Dominican Republic, Guatemala, and Peru have extended subsidies to private operators willing to develop in rural areas. However, before any plans can be implemented, substantial changes need to be made to restructure the Bangladesh Telegraph and Telephone Board (BTTB). A government-owned monopoly, BTTB dominates the telecommunications market. After substantial governmental restructuring of BTTB, telecommunication reach can be increased through privately owned and operated PCOs. As of 2012, the government owned 85% of the fixed line (for example, PTSN) market shares. In contrast, the mobile service market is much more open compared to fixed line, as there are six mobile operators, including non-profit organizations, foreign companies, and private investors (“The Bangladesh Communications Market”). Thus, a much more sustainable route for the fixed line market is to follow the structure of the mobile service market and eliminate the monopoly. In the meantime, mobile services will continue to lead the way toward greater connectivity.

As stated earlier in the paper, even those with access to mobile phone technologies tend to use them for socialization and entertainment purposes. In order to use mobile technologies as productively as possible, rural Bangladeshis will need to shift the usage to business, agricultural, and healthcare applications. A major barrier for the effective use of mobile phones is the lack of intermediaries, or people that work as interfaces between ICTs and rural users. Because of this problem, D.Net (Development Research Network) started the ‘Pallitathya Programme’ to diagnose, identify, and treat pests and diseases, along with other general information about livelihood and health via mobile phones to rural farmers (Liyana). D.Net hired women in four villages near Dhaka to serve as “Mobile Operator Ladies” who traveled door-to-door to provide assistance (“D.Net: Pallitathya Help Line”). This approach can be implemented in other rural areas to provide employment opportunities for women as well as improvement in farm productivity.

Another approach for mobile phone integration was to establish an online mobile trading platform. This platform, called FarmerNet, was established in Sri Lanka for rural farmers, who were constrained by farm-to-market access (Liyana). FarmerNet used Spot Trading platforms to match rural farmers with traders, informing them through SMS texts. This type of Spot Trading platform can be implemented in Bangladesh to integrate mobile phone technology and ICT to increase farm-to-market access.

Conclusion

Bangladeshi smallholders are faced with many challenges, ranging from poor farming strategies to sweeping structural inefficiencies. Therefore, proposed solutions must be comprehensive to address these complex challenges. This paper aims to improve the livelihood rural farmers through the improvement of access to markets. Three main forms of infrastructure were identified and discussed: physical road development, rural electrification, and information and communication technologies. They directly affect the rural smallholder’s ability to access markets and other essential needs. All three sectors studied in this paper are interrelated, as successful deployment of an individual sector will boost the others. For example, electrification of rural communities relies on sufficient road infrastructure to transport resources, while development of ICT also depends on the availability of electricity. Furthermore, successful implementation of all three sectors will facilitate the inflow and outflow of materials and information, and build rural farm-to-market capabilities

The integration of all three factors will decrease isolation of rural communities and increase farm-to-market access. Moreover, it will mobilize the poor through both physical and information access. The underlying theme of the developments proposed in this paper is empowerment of rural poor, women in particular. Many service jobs will be created through these initiatives and will give employment

opportunities to disadvantaged women. Consequently, these women will further the integration of marginalized communities into the national economy and culture. Because such change requires great effort, a multilateral approach involving government, the private sector, and the farmers themselves must be adopted to effectively address these issues. The path out of poverty is by no means easy, but through willing collaboration, the lives of millions can be improved.

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