

SUSTAINABLE DEVELOPMENT OF AGRICULTURE IN BANGLADESH: ACHIEVEMENT AND CHALLENGES

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ABSTRACT

Agriculture-based rural economy of Bangladesh contributes a significant portion to GDP; alleviate poverty and the determining factor for food security. The main obstacle to development of agriculture is the limited supply of land for cultivation, negligence of technology adoption and climate change. Thus, the study was undertaken to make an in-depth review study to fill in the knowledge gap in the way of achievement and challenges in sustainable agriculture production in the country. The study used the secondary information to provide a general view on prospect and challenges of crop sector and suggested necessary measures based on the present analytical review. Cropping intensity increased in the last two decades due to rapid expansion of irrigation, use of fertilizer, crop diversification and a number of policy initiatives by government. Double and triple cropped lands have been increased 37.6% and 273.5% respectively in the last 4 decades. Irrigated area has been increased 4 times in the last 3 decades whereas rice production has been increased 3.33 times in the last 45 years. Low increasing trend of agricultural production attributed to gradual loss of cultivable land, lack of intervention, adoption and dissemination of new technology, lack of sufficient support for agricultural research and training. Technology transfer capacity of extension and research needs to be developed to overcome the present slow and weak research-extension-farmer-market linkage. Agro-ecosystem could be improved using appropriate soil and crop management techniques and enhancing research and extension services and by increasing national and international collaborations.

Key words: Achievement, challenges, cropping intensity, food production and land utilization,

I. INTRODUCTION

Sustainable development is development that meets the needs of the present without compromising the ability of future generations to meet their own needs (Rankin, 2014). The prime aim of sustainable agricultural development is to secure enough food for present and future generations (Zhao et al., 2007). Thus, the issue of greatest concern in Bangladesh's sustainable agricultural development at present is whether agricultural production can ensure food security for the future. Sustainable agriculture is defined as a system that, "over the long term, enhances environmental quality and the resource base on which agriculture depends; provides for basic human food and fiber needs; is economically viable; and enhances the quality of life for farmers and society as a whole" (Crews et al., 1991; Flora, 1992 and Kambewa, 2007). From this statement numerous definitions emerged but the concept surrounding agricultural sustainability remains the same. Also sustainable agriculture is defined as a commitment to satisfy human food and fiber needs and to enhance the quality of life for farmers and society as a whole, now and into the future (M S Abubakar and M L Attanda, 2013). Sustainable agriculture emerged as part of a growing critique of the negative environmental consequences of unquestioned modern farming methods (Keeney, 1989). It is essential that innovative technologies are used to ensure sustainable agriculture and productivity using, modern irrigation systems, improved varieties, improved soil

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quality and conserving the environment using resource conservation technologies (Dover and Talbot, 1987).

Bangladesh is an agro-based developing country in the world, desires to be a medium developed country by 2021. To achieve this vision, the main constraint is the inefficient agricultural production and higher food insecurity of the country. The development of country and achieving food security depends on increased agricultural production and improvement of many other dominant development factors. It is often argued that there are significant potentials for raising agricultural output and profitability by improving production efficiency using existing resources. Over the last two decades, the country experienced robust economic growth and it expects to achieve further growth in the coming years. However, it is one of the most vulnerable countries in the world affected by climate change and natural disasters as one third of its flat land frequently submerged by floods. Thus, significant progress in promoting economic growth, reducing poverty and enhancing food security cannot be achieved without realizing more fully productive capacity of the agriculture sector and enhancing its contribution to overall economic and social development. A strong and vibrant food and agricultural system thus forms a primary pillar in the strategy of overall economic growth and development.

The performance of agriculture has an overwhelming impact on major macroeconomic objectives like increasing farm income, employment generation, poverty alleviation, human resources development and food security. Three-quarters of the total population and 85% of the poor lives in rural areas (GSMA Intelligence, 2014) and 47% of the working population is engaged in agriculture (Bangladesh Economy Profile, 2018), which means the agricultural sector is one of the most important sector to alleviate poverty in Bangladesh and contributes a significant portion to GDP. Thus, the economy of Bangladesh is primarily an agriculture-based rural economy and its development heavily lies on the development of agriculture. As such, a very high priority has been accorded to the programs of agricultural development with a view to accelerating the tempo of economic development in the country. Currently, the proportion of rice acreage is as high as about 76% (BBS, 2014) and farmers have been trying to diversify crops and to add values in their products. Thus, it is important to address these issues and improve livelihoods of farmers. Agriculture is the determining factor for food security as well as pro-poor development of Bangladesh economy. The main obstacle to development of agriculture (especially, the crop sector) is the limited supply of land for cultivation, negligence of technology adoption, climate change and sea level rise. But this sector remains the major contribution to achievement of self-sufficiency in food and rural employment.

The study will provide a brief presentation on trends of crop production, the national agricultural policies undertaken by government, find out the major inconsistencies/challenges of its future development and will finally provide a set of policy prescriptions to tap the maximum potentials of this sector. The study might be helpful to device agriculture and rural poverty policies and reducing problems of underemployment and low levels of living of the poor in some extent. The findings of the research will provide a premise for the agriculturists, economists, food and nutrition scientists, planners and policy makers to draw a policy decision for national development on agriculture. The existing research has, therefore, been undertaken to make an in-depth review study to fill in the knowledge gap in the way of achievement and major constraints in agricultural production in the country. The specific objectives are: (i) to review the achievement in agricultural production in the last four decades, ii) to know the policy initiatives to increase agricultural productions; and (iii) to identify and interpret the major obstacles that challenges development of agriculture.

II. METHODOLOGY

In this study, achievements of agricultural production in the last four decades in Bangladesh were reviewed and major challenges of agriculture to achieve sustainable development goals were revealed. For this reason, the statistics and relevant facts related to agriculture production, initiatives taken by government and major challenges were scrutinized. This study was based on review of national data and policy documents of agricultural development. The study used the secondary information to provide a general view on prospect and challenges of crop sector and suggested necessary measures based on the presently available analytical review that may have to be pursued in future in Bangladesh. Gross cropped area was measured as the total area sown once as well as more than once in a particular year whereas net cropped area was measured as the area sown with crops was counted only once. Cropping intensity was calculated as (gross cropped area /net cultivated area) x 100.

III. RESULT AND DISCUSSION

Achievement in Agriculture after Independence

Agriculture sector in Bangladesh, despite the experience of severe famine in 1974, has been consistently enhanced the production of grain since its independence. Bangladesh agriculture contributed 15.89% to the GDP and only crop sector is 8.99% whereas annual growth of GDP by agriculture and forestry is 3.36% (BBS, 2014). Share of GDP and employment in three major sectors in different periods are shown in Table 1. A declining trend in the growth of agricultural sector has recently been noticed, which, in turn, contributed to declining growth in GDP in the country. There was an increasing trend in growth in agriculture from 1990 to 2010 but it has been falling later which has been causing the share of agriculture in GDP to decline over the recent years. For instance, in FY2009-10, the share of agriculture in GDP was 20.29 percent, whereas in FY2010-11 and FY2012-13 the share was 20.01 percent and 18.70 percent respectively (Bangladesh Economic Update, 2014). As a result of this declining contribution of agriculture to national income, the growth of GDP in the country has also been found declining. Similarly, employment in agricultural sector fell from 78.7 percent in 1973-74 to 45.1 percent in 2015-16.

Table 1: Percentage Share of Major Economic Sectors and Employment involved

	GDP (%)			Employment (%)		
	Agriculture	Industry	Other Economic Sectors	Agriculture	Industry	Other Economic Sectors
1973-74	59.4	6.3	34.3	78.7	4.8	16.5
1980-81	46.7	10.1	43.2	72.7	9.3	18.0
1990-91	30.4	15.8	53.8	66.4	12.5	21.1
2000-01	24.1	18.0	57.9	51.2	10.3	38.5
2004-08	19.1	20.3	60.6	48.1	11.2	40.7
2011-12	17.3	28.6	54.1	45.0	30.0	25.0
2015-16	14.8	28.6	56.6	45.1	20.8	34.1

Source: BBS of different years

In agriculture, cropping intensity, along with the cropping pattern, plays the vital role in production system since the cultivable land areas have continuously been decreasing. Given the law of diminishing marginal returns, such continuous reduction in cultivable land has been

exerting adverse impact on the growth in agricultural sector, resulting in recent declining growth in the sector. Statistics suggest that between the periods from 1961 to 2007, the agriculture experienced a two-fold reduction in the availability of cultivable land. Production during this period increased due mainly to the use of input by the farmers at a higher rate on the same piece of land. For instance, one metric ton of food was produced from 0.406 hectare of land in 1961, whereas same production was achieved from the land below 0.14 hectare in 2007 (Basak, 2012). The land resource of Bangladesh totals about 25.35 million hectares and is cultivated with moderate intensity. Number of holdings (both farm and non-farm) is increasing due to increase of vast population every year. The per capita land holding decreased from 0.12 hectares in 1971 to 0.08 hectares in 1981 and then to 0.07 hectare in 2005 (BBS, 2006) and 0.06 hectare in 2016 (FAO, 2018). The main obstacle to development of agriculture (especially, the crop sector) is the limited availability of land for cultivation. But, this sector remains the major contributor to increasing farm income, achievement of self-sufficiency in food and rural employment. The crop-man ratio in Bangladesh has fallen dramatically from 0.132 to less than 0.094 indicating per capita cultivable land reduction equals to 28.79 percent and land degradation by river erosion was 1.3 million hectare, by soil fertility declined 4.2 million hectare; sulfur deficient (for upland crops) 4.6 million hectare (Dey et al., 2013).

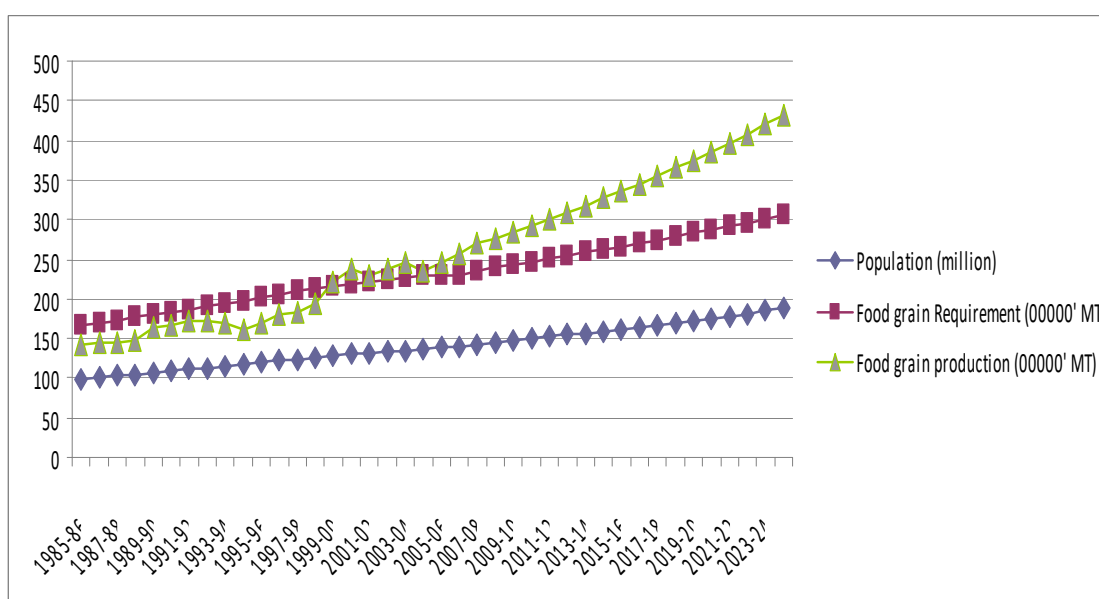
The cultivated land is double and triple cropped where climate and other conditions permit. Total cropped land was 12.22 million hectare in early seventies, 14.03 million hectare at the early nineties, 14.305 million hectare at the early two thousands and 15.444 million hectares in recent years (Table 2). Net available land for cultivation has been decreasing in the last 35 years except 2000-2001. The annual growth of land utilization highly fluctuated for various crops. Of the total cultivated cropped land, 60.5% was single cropped, 33.9% double cropped, and only 5.6% triple cropped in 1972-73. The proportion of single cropped land was decreasing and the proportion of double and triple cropped land was increasing in the last four decades and these figures became 28.3%, 49.3% and 22.2% respectively in 2015-16 (Table 2). Cropping intensity increased substantially in the last two decades due to rapid expansion of irrigation that helped multiple cropping. The harvested area of rice covers 11.5 million hectares (because of 2-3 crops per year) or 80% of the cultivated area on 8.0 million hectares of land, so the cropping intensity for rice alone was 1.43, but increases to 2.28 when all field crops were considered (Gumma et al., 2012). The average annual growth rate of food grains during the period 1972-73 to 2016-17 was 2.89%. Irrigated area increased about 4 times in the last three decades by using deep tube wells and power pumps. By introducing irrigation facilities for dry seasons and high-yield cultivars, it has almost achieved self-sufficiency in food-grain production which has increased to a level of about more than three times (35.115 million tons) in 2016-17 (BBS, 2017) compared to 9.99 million tons in 1972-73 immediately after independence. Bangladesh's food gap was 4.6 million tons and this figure was not much fluctuated until 1998-99. After that food gap was reduced considerably and this figure was very low in 2000-01, 2003-04, 2006-07 and 2008-09. The average food gap for Bangladesh from 1971-72 to 1998-99 was approximately 4 million tons which was remarkably reduced to 1.2 million tons in 1999-00 to 2006-07. Latest amount of production and requirements of food grainsⁱ in Bangladesh can be analyzed using the following Figure 1:

Table 2: Trends in Land Utilization Pattern and Cropping Intensity

Year	Single Cropped		Double Cropped		Triple Cropped		Net Cropped Area*	Total Cropped Area*	Cropping Intensity
	Area*	%	Area*	%	Area*	%			
1972-73	5,116	60.5	2,846	33.9	472	5.6	8,394	12,224	145.63
1980-81	4,636	54.1	3,254	38.0	672	7.9	9,562	13,160	153.70
1990-91	3,294	40.3	3,899	47.7	981	12.0	8,174	14,034	171.70
1997-98	2,866	36.0	4,085	51.2	1,017	12.8	7,968	14,087	176.79
2000-01	2,891	35.8	4,167	51.5	1,027	12.7	8,085	14,305	176.93
2010-11	2,237	28.6	4,109	52.4	1,486	19.0	7,841	14,950	190.66
2015-16	2,253	28.3	3,915	49.3	1,763	22.2	7,948	15,444	194.00

• indicates '000' hectares

Source: Yearbook of Agricultural Statistics of different years

**Figure 1: Food Production and Requirement Trends in Bangladesh**

Major agricultural products are rice, jute, wheat, potato, pulses, sugarcane, tea, tobacco, etc. Tea, leather and frozen shrimp are also major foreign exchange earners. Bangladesh grows a wide variety of crops which are broadly classified into two groups according to the seasons; Kharif crops and Rabi crops. Rice is a dominant food crop of Bangladesh and as such, it is a crucial part of the national economy. Agricultural production in Bangladesh has steadily improved during the last four decades principally due to dramatic increases in rice production. Total production of rice was 9.8 million tons in 1971-72, which has increased to 13.9 million tons in 1980-81, 17.8 million tons in 1990-91, 25 million tons in 1999-00 and 30.5 million tons in 2009-10 (Quddus, 2012) implies that rice production increased to 3.1 times by 39 years. Remarkable progress has been made in rice production during the last 15 years. Figure 2 shows the increasing trends of production and consumption of total rice from 1985-86 to 2012-13. Domestic production of rice

increased from 15 million metric tons in 1985-86 to 33.82 million metric tons in 2012-13. Rice consumption has been increased rapidly (Figure 2) due to rapid increase of population in Bangladesh. Rice production has also been increased close parallel to consumption except a few years 1988-89, 1994-95 to 1999-00 and 2004-05 to 2008-09.

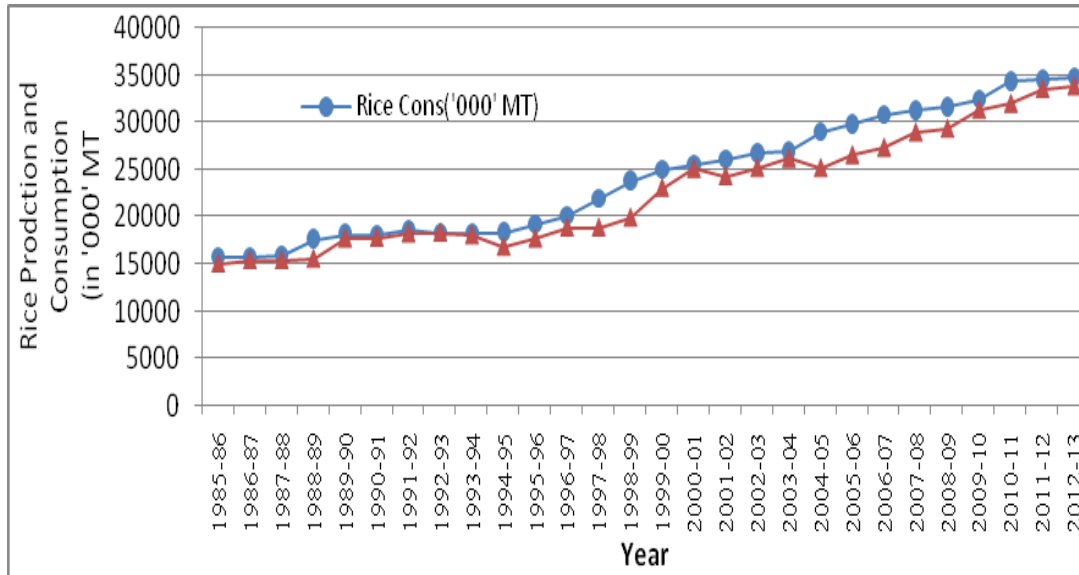


Figure 2: Trend in Production and Consumption of Rice

Next to rice, wheat is the most important crop in Bangladesh which is grown mainly in the drier parts of north and is cultivated only as a winter crop. Bangladesh grows potato and vegetables sufficiently due to favorable weather condition and hence financial support and technical assistance on these sub-sectors would be useful. Pulses are the important dietary component of the people of Bangladesh, especially, for rural people. After Independence, pulses production was too small for domestic demand. Then, Government has taken some policies for increasing pulses production. For this reason, the dramatic changes occurred in pulse production from 1982-83 to 1997-98, then its production shows declining trend because of loss of areas for Boro rice and other winter cash crops. Jute leads the country's list of export crops confined mainly to the low-lying areas of the Brahmaputra-Jamuna and Padma floodplains. Mustard (including rape) is an important crop which is also grown mainly in the low-lying areas of Brahmaputra-Jamuna and Meghna floodplains. Potato is the most important winter vegetables and is widely grown. Tea, a minor crop in terms of area, comes second as an export crop which is mainly grown in the hills.

The scenarios of growth rates in agricultural sub-sectors indicate that the decline in overall growth in agriculture is mainly due to fall in the growth of crop production. While the growth of livestock and forestry is witnessing an increasing trend, the growth in crops is substantially declining. As a result, the share of agriculture in GDP is largely declining, since the crop production that renders the major contribution to national income from agriculture sector is growing at a decelerating rate over the recent periods. Consequently, increasing trend in the growth of livestock and forestry does not compensate the decline of growth in crop production. Meanwhile, contribution of fisheries to GDP is declining, although the trend of growth assumes an increasing trend.

Agriculture is the main source of raw materials as backward and forward linkages for agro based industries. People living in rural areas and as such, the agriculture determines people's lives and livelihood of this region. Recently, there is an increasing trend in export of agro-processed food products and the export value worth BDT 5,189.4 million in the year 2010-11 i.e. it grew at 25.9% in the year from the previous year (BBS, 2011). In 2012, the annual food production was 31.9 million MT that could meet the annual food demand of 31.9 million MT. Foreign trade of agricultural commodities and agro-processed products has recently changed; export of agricultural commodities included new items like spices and vegetables although export of tea which was exported in bulk quantity, has gone down due to substantial increase in the local consumption. The total export value of agricultural commodities increased in 2010-2011 due to significant growth in demand of several items (namely, beaten rice, dried chilies, prepared foods and others), in the overseas ethnic markets besides improved capacity of the local exporters who receive cash incentives from the government. Export growth in agricultural commodities also propelled by recent marketing support of the embassies and market access facilities. It is worthwhile to mention here that Bangladeshi seed producers are actively pursuing export markets like Vietnam and India for hybrid paddy seeds.

Initiatives Taken by Government to Improve Agriculture Production

In order to maintain self-sufficiency in food and food security, the Government of Bangladesh took some strategies like increasing productivity and additional inputs, reducing yield gap, technological improvement, adaptation or variation, networked and electronic agriculture (E-agriculture), post harvest technology adaptation and finally, changing the food habits of people. Extension services so long have been working with model farmers, contact farmers or innovative farmers who are generally well to do especially or large farmers. Now a day, standard yield for rice, wheat, maize and potato are 2.52, 1.53, 5.30 and 15.00 metric tons per hectare respectively.

During the last two decades, the Bangladesh agriculture sector has achieved success in several areas like inputs based growth (intensive use of HYV/hybrid seeds, irrigation, fertilizer, pesticides, etc.), crop diversification and combined growth (vertical & horizontal). These have been possible due to a number of policy initiatives like National Agriculture Policy [1999; 2009 (draft)], New Agricultural Extension Policy, National Food Policy (2006), National Seed Policy (2002), National IPM policy (2002), Fertilizer Management (Amendment) Act 2009, The Pesticide Act, 2009, Rural Credit Policy (2010) (Farmers friendly) and Land Policy & National Land Use Policy (2001). These policies are explained further in brief:

- a. National Agriculture Policy (NAP) aims at making the nation self-sufficient in food through increasing production of all crops including cereals and ensure a dependable food security system. One of the objectives of NAP is to increase production and supplies of more nutritious food crops and thereby assuming food security and improving nutritional status. It also identifies 18 program areas where actions or policies might be undertaken for achieving its goals and these areas shows that NAP underlines all input and support sectors involved with crop production and identifies issues that need to be addressed to improve their efficiency.
- b. New Agricultural Extension Policy (NAEP) aims at encouraging various partners and agencies within the national agricultural extension system to provide efficient and effective services which complement and reinforce each other, in an effort to increase the efficiency and productivity of agriculture in Bangladesh. The major thrust of this policy is to make provision of efficient decentralized and demand led extension

services to all types of farmers, training extension workers, strengthening research-extension linkage, and helping environmental protection.

- c. National Food Policy (NFP) represents an important departure from the past by applying a comprehensive and integrated approach to food security, including the availability, access and utilization dimension of food security. Three main objectives of NFP are: (i) adequate and stable supply of safe and nutritious food, (ii) increased purchasing power and access to food of the people and (iii) adequate nutrition for all individuals, especially women and children.
- d. National Seed Policy (NSP) aims at providing policy directives to increase production of improved seed both in the public and private sectors and for making best quality seeds available to the farmers on timely basis, and at competitive price. The seed policy emphasized liberalization of import of seed and seed processing machineries, strengthening of quality control and research system and maintaining a seed security arrangement.
- e. National IPM policy is intensified and expanded in order to safeguard crops from pest and combat environmental degradation due to pesticide uses. Collaboration among the local government representatives, extension workers and NGOs are sought to expand this program.
- f. Fertilizer Management (Amendment) Act handled strictly to maintenance its quality, preventing adulteration of fertilizer and its production and import.
- g. Rural Credit Policy aimed at expanding agricultural production and employment generating activities by increasing the flow of credit to the agricultural/ rural sector.

Challenges in Agriculture Development

The above review interprets the gradual development of agriculture in Bangladesh. But this achievement in agriculture is not adequate to ensuring food security for the vast population of Bangladesh. The rate of growth of agriculture and its share in GDP is decreasing. The rate of growth in agriculture came down from 5.24 percent in fiscal year (FY) 2009-2010 to 5.13 percent, and then to 3.11 percent and 2.17 percent in FY2010-2011, FY2011-2012 and FY2012-2013 respectively (Bangladesh Economic Update, 2014). This declining trend in growth of agriculture sector can largely be attributed to gradual loss of cultivable land, lack of intervention, adoption and dissemination of new technology, and lack of sufficient support for agricultural research and training in the country. The governments of Bangladesh have, therefore, been giving priorities to agricultural development with a view to ensuring food and nutritional security and poverty alleviation. Therefore, a profitable, sustainable, and environment-friendly agricultural system is required to achieve these objectives. Agriculture in the country faces problems by a number of challenges every year. These challenges include population growth, climatic hazards, loss of arable land, lack of quality seeds, food habit of people (about 90 percent is rice based), inadequate credit support to the farmers, unfair pricing, insufficient investment in agricultural research and agricultural mismanagement in terms of irrigation, and use of fertilizer and pesticides. The majority are small and marginal farmers who are endowed with poor financial resources and cannot afford high cost of frontier technology. Despite many positive phenomena and policy initiatives, the agriculture sector is still facing challenges as discussed below.

Rapid shrinkage of agricultural land: Land supply and demand and land-use mode are mainly decided by population, economy, society and natural conditions (Li et al., 2001). In Bangladesh, agricultural land is rapidly decreasing due to alternate use for homesteads, population growth, industrial and commercial uses, urbanization growth, increase of roads and highways, establishment of brick fields, river erosion and unplanned extension of fisheries. The huge size of the population, 1087 people per square km (WPR, 2014), is the greatest challenge for sustainable development of agriculture in Bangladesh. Continuous population increase will undoubtedly create increasing demand for cultivated land, grassland and forest. In recent years population control programs have been weakened due to administrative problem of conflict of management among Department of Health Services and the Department of Population Control as well as inadequate funding of the programs. The experience of developed countries indicates that industrialization is always accompanied by cultivated land loss. Cultivated land loss due to industrialization is mainly a consequence of use for construction and urban expansion. Rapid and also unplanned urbanization (currently urbanization is growing 12% per annum) is reducing agricultural lands. More serious environmental degradation caused by inappropriate human activity has caused the shrinkage of cultivated land area and reduction in cultivated land quality, such as land degradation and soil erosion, diversification and sanitation (Zhao et al., 2007). The land loss indeed is very alarming for crop production in Bangladesh. The government prepared a land use policy to stop this trend, but no step has so far been taken. It is a challenge as to how to protect agricultural lands.

Attaining irrigation and fertilizer efficiency: Irrigation, fertilizer and seeds technologies known as “Green Revolution” technologies have been playing major roles in the growth of agriculture production in Bangladesh. Use of irrigation and fertilizers has been increasing rapidly without change of method of application. All agricultural inputs which are involved directly or indirectly in any crop production must be adequate and accessible at farmers’ field during the total growing season. Flooded irrigation and broadcasting of fertilizers cause low efficiency of both irrigation and fertilizer. It is a great challenge to innovative methods of irrigation and fertilizer applications such as sprinkler, underground dropping irrigation or deep placement of fertilizers, and use of composite or liquid fertilizers. Therefore, food production can be increased through increasing irrigation facilities together with HYV. It is well known fact that irrigation is the key variable which explains the variation in value productivity because it determines the use of other associated inputs such as fertilizer use, index of mechanization as well as the cropping intensity (Grewal and Rangi, 1983). However, under the current irrigation systems, contribution and management of surface water is inadequate. There is an urgent need to introduce measures to increase the use of surface water for irrigation and other uses. There is also a need to develop and invest in methods for holding wet season water in view of the long history of inefficiency of surface water management, and considering the strategic role of surface water in Bangladesh agriculture. Expanded use and availability of surface water will reduce the pressure on STW and will also reduce the cost of water. Furthermore, subsequent measures should move in tandem with the development of surface water use in a comprehensive and consistent manner. Fertilizer is considered to be one of the main inputs for increasing crop yields and farm profit for any country but balanced fertilization is the key to efficient fertilizer use for sustainable high yields. Therefore, it is necessary to increase the production of all types of fertilizers both chemical and organic in domestic level. Under such situations, there is no alternative but to add organic fertilizer in the soils to sustain crop productivity and to increase fertility. Government can take some public awareness media activities and advocacy to influence farmers for using balanced fertilizer dose and can emphasize the use of organic fertilizer for rice production in Bangladesh.

Therefore, timely supply and availability of fertilizers at reasonable prices at the doorsteps of the hard working farmers in the country is necessary for optimum supply of nutrients to the depleted soils for successful achievement of the targeted agriculture production.

Attaining seeds efficiency: Contribution of private sector and NGOs to quality seed production is still insignificant because they have costly seed preservation and processing facilities. It may be noted that farmer's low quality seeds still meet about 95% seed requirement that is considered to be one of the major constraints to crop productivity. Farmers are still facing difficulties in accessing high-quality seeds. For the solution of the seed problem, research and development of high-quality, mass-produced seeds sold at reasonable prices must come from research institutes, universities, the central and local governments, non-governmental organizations and farmer groups. Basic skill is also lacking in seed management with respect to research, extension, production and marketing which are hindering increasing supply of quality seed. In this context, biotechnology research is necessary along with socioeconomic research. Private sectors are investing in biotechnology and importation of hybrid seeds, but their scope is limited. However, supply of quality seed compared to demand is inadequate in Bangladesh. Rice production can be increased easily by increasing supply of quality seed.

Improper use of fertilizer and pesticides: Pollution caused by indiscriminate and over use of pesticides and fertilizers has become more serious in agricultural environmental systems. Moreover, the deficiency of organic fertilizer use has resulted in a decrease in soil organic matter, unbalanced soil nutrition and a decrease in fertility. Farmers use plenty of pesticide to boost production and they are unaware of the dangers of pesticides and do not take any preventive measures when spraying. Despite government efforts to control pesticide misuse, farmers continue to expose themselves. The Department of Agricultural Extension on pesticide use said 89 percent of farmers used medium to strong chemical pesticides for vegetable cultivation. Besides, incidence of diseases and pests is very severe due to the adverse effects of climate change, particularly rise in temperature. It is estimated that 4-14% of rice yield in Bangladesh is lost every year by different insect pests. Bacterial leaf blight and nematode are now the serious diseases in rice. But the technologies resistant to pests and diseases are still very limited. It is necessary to take effective measures to control fertilizer and pesticide abuse and improve efficiency in fertilizer and pesticide use to achieve more sustainable agricultural production and agro-ecosystems.

Extension services, technology transfer and agricultural research/ education: The agricultural sector extension service plays a key role in disseminating knowledge, technologies and agricultural information. The extension service is one of the critical change agents required in transforming subsistence farming to a modern and commercial agriculture to improve productivity. Bangladesh has a well-developed agricultural research system but in some places use of modern science and technology in agricultural production is still limited where farmers are found continue to use outdated and ineffective technologies. This brings the need of extension services that can link research and the farmers. Transferring updated information and technologies to the field is very important to reduce yield gap and increasing productivity. Despite of recent expansion of research and extension systems, updating information is weak due to weak research-extension-farmer-market linkage resulting slow technology transfer. Technology transfer capacity of extension and research needs to be developed. Poor rural roads and other key physical infrastructure have led to high transportation costs for agricultural inputs and products. It also leads to spoilage of perishable commodities during transportation. This causes high losses to farmers. Weak agricultural research is resulting weak technology generation due to lack of high

level research expertise, and adequate funding. Agriculture education system has been rapidly expanded. There is manpower shortage and adequate funding to develop teaching infrastructure and logistics. Up-gradation of course curriculum is also required as agriculture is gradually transforming to commercial in nature.

Inadequate value addition, food processing and post-harvest losses: Farm level handling, packaging, preservation and transportation facilities are virtually absent. These tasks are still traditional resulting a very high level of post-harvest loss ranging from 10% in grain to 40% in fresh fruits and vegetables. Besides, value addition through processing, packaging and storages is growing very slowly in the private sector due to lack of access to technologies and adequate finance. It is also causing supply chain problem as urban population is demanding increasing volume of quality foods for which capacity of farming population needs to be upgraded with improvement of infrastructure and marketing systems. Farmers are increasing use of machineries. Trans-planters and combined harvesters have been introduced by private companies but their use is still at a very low level due to lack of finance and leasing facilities. Post-harvest losses are caused by poor handling and storage facilities. Extension services can be instrumental to help reduce pre and post-harvest losses caused by the above factors. Shortage of agricultural labor at peak planting and harvest seasons has been emerging as an acute problem. It is also caused by migration of both skilled and unskilled population from rural to urban areas for seeking employment, resulting seasonal labor shortage leaving behind less capable people in agriculture.

Sustainable agro-ecosystem: Bangladesh has a wide range of soil, hydrology and climate conditions, with 30 well-defined agro-ecological zones; often differing in the growers' socio-economic backgrounds. Coastal region of Bangladesh covers over 30% of the total cultivable lands where the soils are poor in organic matter content (<1% to 1.5%). Agro-ecosystem in this region has been degraded due to climate change along with sea level rise, high salinity, high intensity of cyclones and other natural hazards. The rice growth on soils with high salinity levels in this region can be hardly achieved and if harvested the rice is of poor quality for self-consumption. It is justified by the recently encouraging field experiments in southern parts of Bangladesh for saline resistance varieties. A repetitive improved paddy variety termed as "BRRI Dhan 47", can tolerate high salinity levels at seedling stage and during the whole cultivation period. Use of DTW shows the discernible improvement of rice production mainly caused by groundwater use in the northern part of the country. The Barrind Multipurpose Development Authority (BMDA) has established extensive groundwater irrigation system in Rajshahi where the pumping systems are equipped with sub-surface water pipes for reducing evaporation, friction, and leakage losses normally observed in the open canals. The rapid increase of individual tube wells together with the higher groundwater (submersible pumps are installed in a depth of about 70 meter) demand from connected farmers has alerted the BMDA for the establishment of better groundwater conservation practices.

Climate change adaptation: Bangladesh is extremely vulnerable to the impact of climate change, in part because it is low-lying and very flat country, subject to river flooding and vulnerable to sea level rise. Several studies indicated that climate is changing and becoming more unpredictable every year and in near future the earth's oceans will expand, rising sea level, intrusion of saline water in agricultural land and reducing the amount of land available for agriculture. Flood and water logging in the central region, flash-flood in the northeast region, drought in the northwest and southwest region, and salinity intrusion and coastal inundation in the coastal region would be a more acute problem in future. Apart from extreme temperature, natural

disasters like cyclone and tidal surge cause immense loss and sufferings through destruction of forage crops as well as housing. It is revealed from last 25 years flood history that now once in every 4 to 5 years, there could be a severe flood that may cover over 60% of the country and cause loss of life and substantial damage to infrastructure, housing, agriculture and livelihoods. A warming climate could cut crop yields by more than 25% and agriculture and land use change are also responsible for between 19–29% of global greenhouse gas emissions (World Bank, 2014). Agriculture is extremely vulnerable to climate change, higher temperatures reduce yields of desirable crops while encouraging weed and pest proliferation and the overall impacts of climate change on agriculture are expected to be negative, threatening global food security (Nelson et al., 2009).

The north-east of the country is characterized by highest rainfall and relatively low temperature compared to annual average of the country. Sylhet region is highly vulnerable to river flood, flash flood, intensive rainfall and land slide. The northwest region is characterized by high temperature and low rainfall compared to average condition of Bangladesh which is primarily prone to drought which is likely to become more frequent and intense along with horizontal expansion due to climate change. Drainage congestion and water logging is very likely in the coastal regional as a result of combined effect of higher sea water levels, subsidence, sedimentation of estuary branches, higher riverbed levels and reduced sedimentation in flood-protected areas. According to Intergovernmental Panel on Climate Change (IPCC, 2007), coastal area of Bangladesh may go under saline water by 2050. The country has very little preparation for meeting this challenge. Besides due to climate change there is very frequent occurrence of drought, flood, cyclone, and salinity. As a result, soil fertility, crop productivity, and food security would be seriously threatened. But very limited technologies are available that are tolerant to flood and drought. In Bangladesh, about 1 million hectare of the coastal region is saline, but very few varieties are available for combating salinity. Due to the rise in temperature, crop production will be reduced by about 30%. Climate change, especially temperature rise would decrease the yield of *boro* rice by 55-62% and wheat by 61% by 2050 in Bangladesh (Mondal, 2010).

Miscellaneous problems: Despite the scope of higher growth in agricultural productivity, there are also some limitations to agricultural productivity growth those are caused by a number of interrelated problems, among the major ones, problems related to delivery of agricultural credit, high costs of inputs for agricultural production, lack of diversity in use of land, poor marketing and storage facilities of agricultural products, and weak farm and non-farm sector linkages. The marginal and smallholder farmers in Bangladesh often face challenges in managing their production activities as well as exploring crops diversification options and increased value addition due to lack of adequate knowledge and skills and access to market. In recent years NGOs have been targeting to marginal and small farmers for capacity development but their operations are small in remote areas. Besides they are not organized as groups or associations that they can establish access to public and private service providers. There exists an increased number of agribusinesses in Bangladesh with diversified sub-sectors starting from agriculture production, inputs up-to the processing activities for both local and export markets.

IV. CONCLUSION AND RECOMMENDATION

Capacity building of marginal and small farmers in high value crops (HVC) production and post-harvest technologies are very essential. There is need to develop stress tolerant varieties of crops due to climate change. Accelerated production of the minor crops such as pulses, oilseeds, vegetables, fruits, spices, etc, will improve nutritional status of the people and generate rural employment by increasing multiple cropping with improved technologies.

Farmers should gradually reduce their dependence on the use of chemical fertilizers to maintain soil fertility. Irrigation should be applied at the appropriate growth stages of crops for efficient use of water. For quality seed production, farmers should be given massive training on seed production, preservation, and processing. It is also important to support them through credit supply on easy terms and at low interest rate. Farmers should be trained on safety measures of pesticide use and there should be a strong food inspection system to avoid food-borne diseases. Safe pest management should be promoted to avoid danger caused by pesticides and use of pesticides may be avoided by using good seeds and taking some initiatives of changing in agricultural systems.

Farm level handling, packaging, preservation and transportation facilities should be improved by technological and financial interventions to reduce post harvest loss. Storage facilities may be established in rural areas to allow farmers to store their produces and sell the same at better prices. Also, the government might encourage establishing farmers' cooperatives to ensure fair price of their produces. Develop new approaches for supporting small-scale agribusinesses in rural areas such as loan guarantees, underwriting debt, providing equity funds, providing grants for social infrastructure, community projects and better methods for accessing market information.

Technology transfer capacity of extension and research needs to be developed to overcome the present slow and weak research-extension-farmer-market linkage. Also, there is demand for financial assistance and need for facilitation of transfer of modern technology and capacity building for marginal and small farmers for their continued production activities. Farmer's production environments and the impact of adopted technologies must be assessed and the findings adequately used in the planning process.

To restore "ecological health" in agricultural systems energy and resource overuse should be curtailed. Energy and resource conservation, environmental quality, public health, and equitable socioeconomic development should be considered in making decisions on crop species, rotations, row spacing, fertilizing, pest control, and harvesting.

Agro-ecosystem could be improved through using appropriate soil and crop management techniques, saline tolerant and high value crop varieties, improve agro-ecosystem by green agriculture, practicing IPM, enhancing research and extension services and by increasing national and international collaboration. It is essential to have climate adaptation planning in such a way that conserves and sustains the ecosystems and support the poor to the changing circumstances. Strong political commitment must be ensured to implement the present "Climate Change Strategy and Action Plan".

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