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Sustaining agricultural system in Bangladesh: a case study on villages along the Ganges River

（バングラデシュにおける持続的農業システム
−ガンジス川流域における農村の事例研究−）

It's a well-known fact that many developing countries including Bangladesh are facing challenges including population growth, low management mechanisms, agricultural resources scarcity, and environmental degradation, however the government has made great effort to solve those challenges. The agricultural land use has been changing rapidly from last three decades due to unplanned and uncontrolled urbanization, industrialization and increase of population. The population is still increasing by 1.26% every year, however, the cultivated land is decreasing simultaneously. This pattern seriously calls for food security and agricultural land. In 2012, there were 6.0 million hectares of available agricultural land where in 1980 it was 9.0 million hectares. It is anticipated that arable land will be declined from 0.065 ha per capita to 0.025 ha by 2050. In 2008, Bangladesh imported 11.5% of total availability and it is also predicted that until 2021, the demand of staple food will also exceed supply which indicates that demand will also remain higher than production.

In this situation, mechanization has changed many countries economy, life standard, and food security. Agricultural mechanisation has also come to occupy an important place in Bangladeshi's economy and food security efforts. However, many developed countries, such as Japan, had already become fully mechanised for land preparation, pumping and threshing by 1960, while Southeast Asia continued to rely on animal draft power. Scientists have said that to meet demands for agricultural products, global crop production must double by 2050. Many critics of mechanisation have argued that the widespread use of labour-saving technologies has had serious equity consequences, including the displacement of labour and tenant farmers from labour-intensive operations. However, the evidence indicates that these equity consequences have not been as severe or as widespread as presumed. The introduction of new instruments to the agricultural sector in Bangladesh has not only alleviated the labour burden but also helped to increase overall agricultural production.

Several studies on farm mechanisation and its effects on agricultural productivity in Bangladesh are available. Ratan Dha (2018) investigated the impact of fertiliser use on crop productivity in both mechanised and traditional methods and found the benefit-cost ratio to be 1.15 times higher in mechanised farming than it was using traditional methods in the northern region of Bangladesh. Another study by Roy and Singh (2008) showed that increased farm power availability and fertiliser use increased crop yields in Bangladesh. They investigated the correlation between increased use of labour-saving instruments and fertiliser use in the agricultural sector using available secondary data from 1950–2006. However, to the best of my knowledge, no study to date has investigated the impact of the mechanisation of agriculture at the local scale specifically in the Ganges flood plain area, which remains largely dependent on agriculture.

To complete my research, priorly, I made a literature review to achieve a clear concept of my research topic. Here, I followed many researchers who have a strong knowledge, research paper and experiences on the same research field. Among them "Abdul et al., 2016; Aryal et al., 2019; Mottaleb et al., 2018; Paudel et al., 2019; Justice and Biggs, 2013; Pingali, 2007; Rahman, 2017; Roy and Singh, 2008; Shelley et al., 2016; Takele and Selassie, 2018; World bank, 2015" etc. are most mentionable researcher on this research area. These prominent researchers have a strong positive opinion towards agricultural

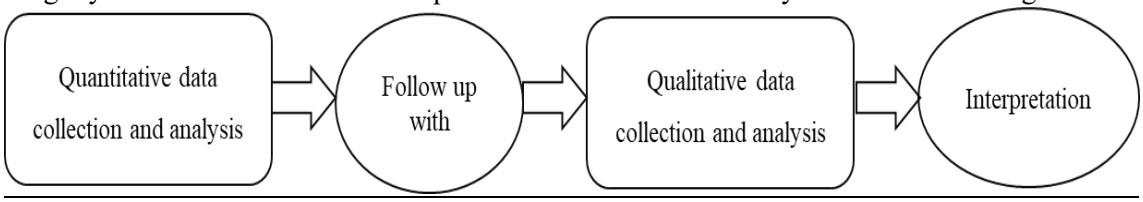
mechanization, challenges and factors of adopting mechanization.

In introductory chapter 1, I have outlined the research objectives, the key research question, and identified the various GOs and NGOs involved in the research. I have conducted an extensive literature review of the main themes discussed throughout the research (i.e., agricultural systems, farm mechanization, productivity, farmers' perceptions of farm mechanization, the effects of farm mechanization on their socio-economic development, etc.), examining the work of other scholars and scientists in the same field or context and assessing the state of the literature. Drawing on the relevant literature, I have provided definitions of the key terminology. Like many other scholars, I prioritize the FAO's definition over other definitions. I investigated how agriculturists have approached the assessment of farm mechanization both globally and in the context of Bangladesh as well as other developing countries. In the chapter that follows, I will proceed to define the problem statement for the study area and detail the rationale behind the selection of the study area. Subsequently, I will focus on the field survey used to gather data from the relevant people and the theoretical analysis of the respondents' perceptions of farm mechanization, the adoption of farm machinery and socio-economic development for the adoption of mechanization.

Chapter 2 has been conducting to reveals the importance of farm mechanization in social livelihood in the Ganges flood plain of Bangladesh through sustainable agriculture system. The mechanization of rural areas, the promotion of sustainable agriculture, and to discuss the elements. I have explained the significance of agricultural development of my study site with a brief overview of challenges of agriculture development in Bangladesh

Chapter 3 assessed existing scenario and challenge of agriculture productivity in Bangladesh; to investigate the possible solution to overcome the challenges of crop productivity (objective 1). Is the mechanized farming system can be a possible option? Critically examine the determinants of farm mechanization and its impact on rural economic development in the rural Ganges floodplain of Bangladesh; and to suggest time-appropriate possible solution for agriculture and rural development in the area (objective 2). This study also investigated the BC (cost benefit) ratio for three types of farmers: traditional, mixed and modern-machinery users; productivity was estimated using the Cobb-Douglas (CD) production function. Hence, the aim of this study was to discover the factors with the greatest influence on crop productivity. We also investigated the effect of crop market prices and farmers' actual earnings in rural areas (objective 3). This study provides significant insight into Bangladesh's agricultural system and suggests some directions that should be followed to ensure food security (objective 4).

I've described briefly about the chapter contents to make easier to understand. Study area, data sources, data collection methods, research methodology, and analysis have been discussed in second chapter. To conducting my research field data are indispensable. I have conducted my field visit following methods.



By gathering knowledge from literature review, both *quantitative and qualitative* research technique were used for this study that includes in-depth interview, questionnaire survey, focus group discussion and participant observation as primary data collection procedure. It is a descriptive and interpretive case study that is analysed through statistical analysis. A production model was employed to quantify the crop productivity. Besides a descriptive statistical method was used to analyze the farm mechanization factors and to assess economic impact of rural society. Finally, in order to ensure trustworthiness of the study, appropriate criteria for quantitative and qualitative research were discussed, and several methods that include validation with, member checks, peer reviews, crystallization and triangulation are suggested.

Respondent selection is very sensitive for better representation of sample data. Selection of wrong respondent or inappropriate ones may provide misleading information conducting research. Besides it also necessary to understand the local context of my research problem. I got the chance to arrange my meeting after that meeting with the request of Upazila agriculture officer who I contacted before. During discussion we identified 12 unions that can be potentially included in the survey. However, due to time and budgetary

constraints, among twelve unions, Mizanpur union of Rajbari district were selected with discussing above officials for data collection which are seriously affected by the flood hazard based on the past knowledge of the elected people. The total households of twelve unions and selected union's housholed for surveying are about 46,000 and 7,666 respectively. Mizanpur unions consists 27 villages/ clusters. Following Yamane (1967) sample size estimation formula. By calculating the number of households, 381 sample were estimated for the survey. Finally, a proportional cluster random sampling was conducted for the household survey.

Findings of chapter 3 have several important implications for future practice. From the findings of this chapter, the current agricultural scenario of the study area and the country can be understood clearly. The findings suggest investigating or emphasizing on the mechanization on farming system that how it can be a possible solution for improving farmers' livelihood and socio-economic condition. So, next chapter reveals the comparative assessment of crop productivity in mechanized and non-mechanized farming system if the study area.

Chapter 4 investigated the importance of farm mechanization for ensuring food security and the rural economy in developing countries in which agriculture is a primary source of household income. Sample data were collected from a total of 381 respondents for comparative assessment of crop productivity among different farmers' groups in the rural Ganges floodplain of Bangladesh. Thereafter, the Cobb-Douglas (CD) production function was employed to estimate Boro rice productivity, and a cost-benefit analysis (CBA) was also carried out for three farming groups (traditional, mechanised and mixed-machinery users). The Production Function estimate the maximum productivity to be 5,917 kg/ha for modern-machinery users, followed by mixed-machinery users at 4,459 kg/ha and traditional farmers at 3,960 kg/ha in 2018. CBA illustrate that according to the Government prescribed crop selling price, the benefit-cost ratio is 1.75, and 1.32 for mechanized and traditional machinery-users farmers respectively. However according to the respondent crop selling price, the benefit-cost ratio is 1.19, and 0.94 for mechanized and traditional machinery-users farmers respectively. Mechanised farmers are the most resilient with respect to any unexpected increase in production costs and selling-price fluctuations. This research will be helpful in drawing government-level decision-makers' attention to agricultural production, with the aim of attaining food security by mechanizing developing countries' cultivation systems.

The marginal effects of input factors can be assessed by estimating functional coefficients. In applying the above formula, we estimated the Boro productivity for three groups of farming households. Farms were categorised based on the use of different types of machinery for cultivation. The Boro productivity for each of the farming groups was estimated in hectares per year using information collected from a field survey. The production model estimated that the benefit-cost (BC) ratio is higher for mechanised farmers and that they are the most resilient with respect to any unexpected increase in production costs and selling-price fluctuations.

Traditional machinery use farmers get 1, 358.15$, mixed machinery user farmers get 1,529.53$ and modern machinery use farmers get 2,029.7$ for per hectare rice production, according to government fixed price. However, based on the farmers' actual selling prices, traditional, mixed and modern farmers get $928.04/ha, $1,045.14/ha and $1,386.91/ha, respectively, because the yield price is significantly affected by the average annual price and harvesting season market price. Hence, according to the respondents' selling price with a 5 percent discount rate, the BC ratio is highest for modern-machinery users (1.194) and lowest for both traditional and mixed-machinery users (0.946 and 0.994, respectively). Because local farmers cannot sell their products directly to the markets, businessmen and local brokers function as middlemen, and they devour the farmers' benefits. Moreover, during harvesting, supply increases as demand declines.

Based on the results of prior research analyses, this study examined the role of farm mechanization in the socioeconomic development of Bangladesh. It also assessed the relationship between a mechanized agricultural system and the growth of household income, and examined the associated socioeconomic variables involved in this relationship. The findings of this study are expected to provide insights into the socioeconomic development of agriculture-based economies of developing countries. One important limitation of this chapter relates to our confidence in the respondents' opinion-based CBA. This chapter (chapter 4) is not directly comparable with detailed socio-economic studies considering that we did not investigate the capability of farmers to implement mechanisation at the household-level. Resulting,

determinants of farm mechanization and household income concerning farmer's socio-economy development have been analysed in the next chapter (chapter 5).

Previous studies for example Aryal *et al.*(2019) investigated the interdependence of small scale machinery use in the coastal area of Bangladesh. They acknowledged that machinery ownership is not necessary for their use as most farmers hire these machine services. Using Multinomial probit model, Khondoker *et al*.(2016b) found that agriculture machinery ownership is positively associated with household assets, capital, credit availability electrification, and road density. A. Islam. (2018) investigated the constraints and prospects of mechanized rice cultivation in Bangladesh. Also Uddin *et al*.(2014) investigated the determinants for adoption of adaptive strategies to climate change. However, to the best of my knowledge, no evidence exits on the factors determining household income and adaptation of modern technology inclusively. It builds upon an idea that the interdependence of mechanized agriculture system and growth of household income are confidently interwoven with each other's. It paints a comprehensive portrait of the socio-economic variables associated with agricultures and their inspiration on farm mechanization and household income growth. The findings of this research will inform the impending of socio-economic development in the developing country when agriculture is the preference option of the rural economy.

In the study area, approximately 52% of respondents resided in a Katcha house, a traditional farmer's house made with bamboo, mud, and raw materials; they had few facilities such as a sanitary latrine, electricity, or mobile phone. Notably, a motorbike, mobile phone, access to uninterrupted electricity, cattle, and sturdier house type are considered items of wealth in rural areas. Approximately 5% of respondents had a pucca (concrete house made with rod cement) and had access to electricity, a sanitary latrine, cattle, motorbikes, and mobile phones. Most farmers who indicated partial use of machinery (43%) had semi-pucca houses (tin shade, mud floors, and tin or brick walls). These farmers had mixed land holdings, especially as marginal and small-scale farmers; they had moderate access to facilities and sanitary latrines. A few partial-use farmers had their own drinking tube wells, whereas some shared a tube well; these farmers also tended to have more cattle than landless or marginal farmers.

The regression model shows agriculture knowledge of machinery use is highly related to household income growth in the study area with statistically significant. The farmers having experience of using machinery and having training shows higher positive coefficient. The findings show that the choice of using agriculture machinery is highly influenced by the previous experience of machinery using. Besides those practice mechanized farming (use of tractor, power tiller, thresher, DTW, and STW), they can also engage others available non-farm activities that also increase their household income (Suvedi, Ghimire, & Kaplowitz, 2017).

Access to agriculture facilities found to have positive relationship with per capita household income. It also reveals that tractor, power tiller, STW, DPW has significant influence on income acceleration. By supporting our findings Hasan et al.(2020) also reported that mechanized agriculture plays a key role in the overall socio-economic development in terms of food security, value addition, employment, poverty alleviation and export earnings. Apart from that Ma et al. (2018); Richards and Ramezani, (1990); Wang et al.(2017) agriculture mechanization increase household income by absorbing extra labor force in off farm activities.

The number of adult family members was observed to have highly significant positive relationship with household per capita income. The income coefficient is increasing with the increasing of adult members. Because extended households are most likely to be engaged in both agricultural and non-agricultural activities. Previously many studies Janvry and Sadoulet (2001); Ellis (1998); Reardon et al.(2007); Sultana (2015) reported that the increasing number of adult family member tend to have earn from diversified income sources. As expected, I found that number of dependent members negatively influence to per capita household income. The findings support by previous evidence by Jansen et al. (2006); Nguyen and Nguyen (2019) who found that having more dependent members and more family members in general tends to reduce per capita income.

Finally, the chapter assessed a binary logistic regression model to observe the determinate factors for choosing farm mechanization and multiple regression model were chosen to observe the influence of socio-economic variables on household income. Our findings suggest that adaption of modern machinery is

driven by the wish of increasing crop productivity and socio-economic development. It reveals that *family members involve in non-farm activities*, *Government training facilities for machinery use*, *experience of using machinery*, and *availability of machinery* is sturdily effects of choosing mechanized farming and household income seriously with those variables. The machinery ownership was not affected significantly for choosing mechanization because our result shows the "rented farming" variables highly positive relation and statistically significant. Rural farmers acknowledge mechanization to increase their household income when continue living with a limited option of choosing others income source.

To sustain this, the agricultural sector requires the availability of machinery. Hence, the level of mechanization requires that the socio-economic conditions of the population be considered. Government market strategies need to be friendly to the agriculture sector and ensure that farmers have access to spare parts for servicing and maintenance of machinery. The government or private sector can also take initiatives to provide locally developed and modified machinery, thereby also introducing small-scale entrepreneurship. Furthermore, institutional linkages among researchers, policy makers, local manufacturers, machinery importers, and rural NGOs should emphasize the adoption of machinery and rural development. Assessment of the results and other researchers' opinions demonstrates that farmers' livelihoods will change significantly through the adoption of mechanization. Finally, it is proven that agricultural mechanization plays a significant role in contemporary socio-economic development and food security. These findings and suggestions may assist GOs and NGOs to assess farmers' associated problems at the community level.

Abdul, K., Krupnik, T. J., Erenstein, O., & Asia, S. (2016). Factors associated with small-scale agricultural machinery adoption in Bangladesh : Census fi ndings. *Journal of Rural Studies*, *46*, 155–168. https://doi.org/10.1016/j.jrurstud.2016.06.012

Aryal, J. P., Rahut, D. B., Maharjan, S., & Erenstein, O. (2019). Understanding factors associated with agricultural mechanization: A Bangladesh case. *World Development Perspectives*, *13*, 1–9. https://doi.org/10.1016/j.wdp.2019.02.002

De Janvry, A., & Sadoulet, E. (2001). Income strategies among rural households in Mexico: The role of off-farm activities. *World Development*, *29*(3), 467–480.

Ellis, F. (1998). Household strategies and rural livelihood diversification. *The Journal of Development Studies*, *35*(1), 1–38.

Hasan, K., Tanaka, T. S. T., Alam, M., Ali, R., & Saha, C. K. (2020). Impact of Modern Rice Harvesting Practices over Traditional Ones. *Reviews in Agricultural Science*, *8*, 89–108.

Islam, A. (2018). Status of rice farming mechanization in Bangladesh. *Journal of Bioscience and Agriculture Research*, *17*(01), 1386–1395.

Jansen, H. G. P., Pender, J., Damon, A., Wielemaker, W., & Schipper, R. (2006). Policies for sustainable development in the hillside areas of Honduras: A quantitative livelihoods approach. *Agricultural Economics*, *34*(2), 141–153.

Justice, S., & Biggs, S. (2013). Rural and agricultural mechanization in Bangladesh and Nepal: Status, processes and outcomes. *Mechanization for Rural Development: A Review of Patterns and Progress from Around the World. Food and Agriculture Organization of the United Nations (UNFAO), Rome*, 67–98.

Ma, W., Renwick, A., & Grafton, Q. (2018). Farm machinery use, off-farm employment and farm performance in China. *Australian Journal of Agricultural and Resource Economics*, *62*(2), 279–298.

Mottaleb, K. A., Krupnik, T. J., & Erenstein, O. (2016). Factors associated with small-scale agricultural machinery adoption in Bangladesh: Census findings. *Journal of Rural Studies*, *46*, 155–168.

Mottaleb, K. A., Rahut, D. B., Kruseman, G., & Erenstein, O. (2018). Evolving food consumption patterns of rural and urban households in developing countries: A Bangladesh case. *British Food Journal*, *120*(2), 392–408.

Nguyen, H. M., & Nguyen, T. A. (2019). Investigating the determinants of household welfare in the Central Highland, Vietnam. *Cogent Economics & Finance*, *7*(1), 1684179.

Paudel, G. P., KC, D. B., Rahut, D. B., Khanal, N. P., Justice, S. E., & McDonald, A. J. (2019). Smallholder farmers' willingness to pay for scale-appropriate farm mechanization: Evidence from the mid-hills of

Nepal. *Technology in Society*, *59*(July), 101196. https://doi.org/10.1016/j.techsoc.2019.101196

Pingali, P. (2007). Chapter 54 Agricultural Mechanization: Adoption Patterns and Economic Impact. *Handbook of Agricultural Economics*, *3*, 2779–2805. https://doi.org/10.1016/S1574-0072(06)03054-4

Rahman, M. T. (2017). Role of Agriculture in Bangladesh Economy: Uncovering the Problems and Challenges. *International Journal of Business and Management Invention*, *6*(7), 36–46. https://doi.org/n.a.

Ratan Dha, A. (2018). Economics of Boro Rice Production in Rangpur District of Bangladesh: Comparative Assessment of Urea Super Granule and Traditional Urea Application. *Agricultural Research & Technology: Open Access Journal*, *18*(3). https://doi.org/10.19080/artoaj.2018.18.556059

Reardon, T., Berdegué, J., Barrett, C. B., & Stamoulis, K. (2007). Household income diversification into rural nonfarm activities. *Transforming the Rural Nonfarm Economy: Opportunities and Threats in the Developing World*, 115–140.

Richards, A., & Ramezani, A. (1990). Mechanization, off-Farm employment and agriculture. In *Labor and Rainfed Agriculture in West Asia and North Africa* (pp. 49–65). Springer.

Roy, K. C., & Singh, G. (2008). Agricultural mechanization in Bangladesh. *Ama, Agricultural Mechanization in Asia, Africa & Latin America*, *39*, 83–93.

Shelley, I. J., Takahashi-Nosaka, M., Kano-Nakata, M., Haque, M. S., & Inukai, Y. (2016). Rice cultivation in Bangladesh: present scenario, problems, and prospects. *Journal of International Cooperation for Agricultural Development*, *14*(4), 20–29.

Sultana, N. (2015). Income Diversification and Household Well-Being: A Case Study in Rural Areas of Bangladesh. *International Journal of Business and Economics Research*, *4*(3), 172. https://doi.org/10.11648/j.ijber.20150403.20

Suvedi, M., Ghimire, R., & Kaplowitz, M. (2017). Farmers' participation in extension programs and technology adoption in rural Nepal: a logistic regression analysis. *The Journal of Agricultural Education and Extension*, *23*(4), 351–371.

Takele, A., & Selassie, Y. G. (2018). Socio-economic analysis of conditions for adoption of tractor hiring services among smallholder farmers, Northwestern Ethiopia. *Cogent Food & Agriculture*, *4*(1), 1–15. https://doi.org/10.1080/23311932.2018.1453978

Uddin, M. N., Bokelmann, W., & Entsminger, J. S. (2014). Factors affecting farmers' adaptation strategies to environmental degradation and climate change effects: A farm level study in bangladesh. *Climate*, *2*(4), 223–241. https://doi.org/10.3390/cli2040223

Wang, X., Huang, J., & Rozelle, S. (2017). Off-farm employment and agricultural specialization in China. *China Economic Review*, *42*, 155–165.

World Bank. (2015). *Updating Proverty Maps of Bangladesh*. Retrieved from http://documents.worldbank.org/curated/en/180321468003309069/pdf/695330ESW0P0780y0Maps0of0Bangladesh.pdf