DETERMINANTS OF ADOPTION OF CONSERVATION AGRICULTURE PRACTICE IN SOME SELECTED AREAS OF BANGLADESH

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CERTIFICATE

This is to certify that the thesis entitled **"DETERMINANTS OF ADOPTION OF CONSERVATION AGRICULTURE PRACTICE IN SOME SELECTED AREAS OF BANGLADESH"**. submitted to the department of Management & Finance, Faculty of Agribusiness Management, Sher-e- Bangla Agricultural University, Sher-e-Bangla Nagar, Dhaka 1207 in partial fulfillment of the requirements for the degree of Master of Science (M.S.) in Management & Finance, embodies the result of a piece of bona fide research work carried out by **RAGIB ANJUM**, **Registration No. 18-09197** under my supervision and guidance. No part of the thesis has been submitted for any other degree or diploma.

I further certify that any help or source of information, as has been availed of during the course of this investigation has been duly acknowledged by the Author.

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DEDICATED TO

MY

BELOVED PARENTS

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ACRONYMS

GoB	Government of Bangladesh
BCAS	Bangladesh Center for Advanced Studies
ADB	Asian Development Bank
BBS	Bangladesh Bureau of Statistics
UNFPA	United Nations Population Fund
IPCC	Intergovernmental Panel for Climate Change
GDP	Gross Domestic Product
CA	Conservation Agriculture
PPP	Purchasing Power Parity
ZT	Zero Tillage
SRI	System of Rice Intensification
DSR	Direct Seeded Rice
GHG	Greenhouse Gas emissions
FAO	Food and Agriculture Organization
NGO	Non-Government Organization
CCAFS	Climate Change Agriculture and Security Food
RDRS	Rangpur Dinajpur Rural Service
IPM	Integrated Pest Management
ICT	Information and Communication Technology
SPSS	Statistical Package for Social Sciences
BNFE	Bureau of Non-Formal Education

A STUDY ON DETERMINANTS OF CONSERVATION AGRICULTURE PRACTICE ADOPTION IN SOME SELECTED AREAS OF BANGLADESH

ABSTRACT

The study was conducted to determine and describe some characteristics of the farmers and to identify the factors that affect the adoption of conservation agriculture in Bangladesh. A total of 100 (i.e; 64 adopter of CA & 36 non-adopter of CA) farmers from two districts were selected for this study. Descriptive statistics and probit model was used to achieve the objectives. Using frequency distribution, it was found that 48.4% of adopter's age lies between 41-50 and 30.6% of non-adopter's age was in the group of 31-50. Most of the adopter and non-adopter farmers have only secondary level education. 82.8% of adopter's have high income whereas 77.8% of non-adopters have high income which is relatively low compared to adopter farmers of conservation agriculture. About 53.1% of adopter farmers belong to small farmers group whereas 77.8% of non-adopter farmers belong to small farmers. That means conservation agriculture practice is relatively more popular in large farmers group than small farmers group. Using probit model, it was found that the farm size, training on CA and drought events in study area has a tremendous contribution on probability of adoption of conservation agriculture. Input support, motivation, training programs and extension services are recommended to implement in order to raise the awareness and enrich the knowledge of the farmers on conservation agriculture practice.

CHAPTER ONE
INTRODUCTION

1.1 Background of the study

The Intergovernmental Panel on Climate Change (IPCC, 2007) predict that developing countries, like Bangladesh, will continue to be affected by extreme weather variability suchas temperature, severe water shortage, and flood-inducing rainfall events during the coming decades. Most predicted consequences of climate change are weather variability and sea level rises with global temperature change by 0.6 °C. Scenarios predict global temperature could increase between 1.4 °C and 5.8 °C by the end of the 21st century (IPCC 2001). Over the 20th century it was observed that about 10 to 25 millimeters rise of sea level and many scholars predicted that this rise will continue in a range of anywhere from 20 to 90 centimeters within the 21st century (IPCC, 2013). the most recent IPCC report has noted empirical models forecasting a lengthening and intensification of rainfall periods, notably the South Asian subsystem of the Asian-Australian Monsoon. The flooding of land areas through sea-level rise and increased rainfall is not the only worrisome effect of global climate change; the IPCC also notes drought events as well. In the final decades of the 20th century roughly 2.7 million ha of land in Bangladesh alone were vulnerable to annual drought with a 10% probability that 41%–50% of the country experiencing drought in a given year (IPCC, 2001 & IPCC, 2013).

Bangladesh is considered to be one of the country's most vulnerable to climate change and its effects on environmental degradation because of its geographic location. These impacts on average temperature and rainfall have a baseline impact on the productive capacity of agricultural activity, altering the underlying yield expectations and risk regimes faced by farmers (ministry of environment & forest 2008). Additionally, the region faces recurrent, climate-related natural disasters; about 174 events such as floods, droughts, and cyclones, have affected Bangladesh from 1974 to 2007. These natural disasters have damaged agriculture and its production in ways that severely affected the farming activities and national economy as well (GoB 2013, Uddin et. al. 2012). By way of example, cyclones hit Bangladesh, on average, every three years, causing serious damage to the people, infrastructure, and agriculture of the country. In 1970 and 1991, cyclones killed 500,000 and 140,000 people, respectively (ADB 2004, BCAS 1991). An estimate made by the Government of Bangladesh (GoB) about the destruction and loss in the country due to the Cyclone Sidr (GoB, 2013) found significant damage to infrastructures, assets, and loss of production; specifically, within the agricultural sector these losses were valued at US $438 million, which accounts for approximately 95% of the total losses to all sectors.

Agricultural intensification, therefore, must focus on achieving food, nutritional, environmental and livelihood security through improvement of farming systems of resource poor small farm holders without harming the environment and conserving natural resources for future generations. The new paradigm of "sustainable intensification" as elaborated in FAO (2011) recognizes the need for a productive and remunerative agriculture which at the same time conserves and enhances the natural resource base and environment, and positively contributes to harnessing the environmental services. Sustainable crop production intensification must not only reduce the impact of climate change on crop production, butalso mitigate the factors that cause climate change by reducing emissions and by contributing to carbon sequestration in soils. Intensification should also enhance biodiversity in crop production systems above and below the ground to improve ecosystem services for better productivity and healthier environment.

Conservation Agriculture (CA) is a model of sustainable agriculture as it leads to profitable crops production while protecting and even restoring natural resources. CA benefits farmers because it reduces production costs and increases yields through the betterment soil fertility, improvement of water quality, reduction of erosion and mitigation of climate change by increasing carbon sequestration, etc. CA systems are also less sensitive to extreme climatic events and therefore contribute to the adaptation to climate change and the resilience of agricultural systems. Hence, CA becomes a fundamental element of sustainable production intensification, combining high production with the provision of environmental services.

CA is gaining acceptance in many parts of the world as an alternative to both conventional agriculture and to organic agriculture. Although the practice of CA on a large scale emerged out of Brazil and Argentina, similar developments were occurring in many other areas of the world, notably North America in zero tillage, and Africa and Asia with technologies such as agroforestry (Dumanski *et al.,* 2006).

CA aims to achieve sustainable and profitable agriculture and subsequently aims at improved livelihoods of farmers through the application of the three CA principles: minimal soil disturbance, permanent soil cover and crop rotations. CA holds tremendous potential for all sizes of farms and agro-ecological systems, but its adoption is perhaps most urgently required by smallholder farmers, especially those facing acute labor shortages. It is a way to combine profitable agricultural production with environmental concerns and sustainability and it has been proven to work in a variety of agro-ecological zones and farming systems. It is being perceived by practitioners as a valid tool for sustainable land management (FAO, 2007).

1.2 What is CA?

Conservation agriculture (CA) is a production system aimed at reducing the effort and cost of farming in a way that protects and improves agricultural soils. CA can be defined by a statement given by the Food and Agriculture Organization of the United Nations as “a concept for resource-saving agricultural crop production that strives to achieve acceptable profits together with high and sustained production levels while concurrently conserving the environment” (FAO, 2007).

Agriculture is one of the most important sectors in the economies of most nations. At the same time conservation is the use of resources in a manner that safely maintains a resource that can be used by humans. Conservation has become critical on the fact that the world population has increased over the years and more food needs to be produced every year. Sometimes referred to as "agricultural environmental management", conservation agriculture may be sanctioned and funded through conservation programs promulgated through agricultural legislation.

CA is the integration of ecological management with modern, scientific and agricultural production. CA employs all modern technologies that enhance the quality and ecological integrity of the soil, but the application of these is tempered with traditional knowledge ofsoil husbandry gained from generations of successful farmers. This holistic embrace of knowledge, as well as the capacity of farmers to apply this knowledge and innovate and adjust toevolving conditions, ensures the sustainability of those who practice CA. A major strength of CA is the step-like implementation by farmers of complementary, synergetic soil husbandry practices that build to a robust, cheaper, more productive and environmentally friendly farming systems. These systems are more sustainable than conventional agriculture because of the focus of producing with healthy soils.

CA is based on enhancing natural biological production levels while processes above and below the ground. Interventions such as mechanical soil tillage are reduced to an absolute minimum, and the use of external inputs such as agrochemicals and nutrients of mineral or organic origin are applied at an optimum level and in a way and quantity that does not interfere with, or disrupt, the biological processes. CA is characterized by three principles which are linked to each other, namely: (1) continuous minimum mechanical soil disturbance; (2) permanent organic soil cover; and (3) diversified crop rotations in the case of annual crops or plant associations in case of perennial crops.

1.3 Principles of CA

Conservation agriculture (CA) holds great promise as the goal of agricultural sustainability, conserving, improving and making more efficient use of natural resources through the integrated management of available soil, water and biological resources, combined with judicious use of external inputs. CA has potential to reduce the negative impacts of intensive agriculture minimizing soil degradation, build up soil organic matter, improve soil physical and biological health; reduce use of fossil fuels and enhance input use efficiency contributing, thereby, reduction of emission of greenhouse gases in the atmosphere. Thus, CA is a base for sustainable agricultural production intensification and complies with the generally accepted ideas of ecological sustainability. According to FAO (FAO, 2014), CA is an approach to manage agro-ecosystems for improved and sustained productivity, increased profits and food security while preserving and enhancing the resource base and the environment. CA is a resource-saving agricultural production system that aims to achieve production intensification and high yields while conserving the natural resource base through compliance with following three interrelated principles, along with other good production practices of plant nutrition and pest management (Abrol and Sangar 2006, Bhan and Behera, 2014).

(i) Minimum soil disturbance: The soil biological activity produces very stable soil aggregates as well as various sizes of pores, allowing air and water infiltration. This process can be called "biological tillage" and it is not compatible with mechanical tillage. With mechanical soil disturbance, the biological soil structuring processes will disappear. Minimum soil disturbance provides/maintains optimum proportions of respiration gases in the rooting-zone, moderate organic matter oxidation, porosity for water movement, retention and release and limits the re-exposure of weed seeds and their germination (Kassam and Friedrich, 2009).

(ii) Permanent soil covers through crop residues or cover crops: Soil mulch protects the soil against water and wind erosion, increases water infiltration, reduces water evaporation, conserves moisture, and helps moderate soil temperature, improves soil structure and aggregation contributes to the accumulation of organic matter, reduces weed infestation, promotes biological soil tillage through their rooting but also by support for earthworm, arthropods and microorganisms belowground and improves soil structure and aggregation, soil biological activity and soil biodiversity besides carbon sequestration (Ghosh *et al.* 2010).

(iii) Crop rotations ensuring a balanced mix of crops: The rotation of crops is not only necessary to offer a diverse "diet" to the soil microorganisms, but also for exploring different soil layers for nutrients that have been leached to deeper layers that can be "recycled" by the crops in rotation. Furthermore, a diversity of crops in rotation leads to a diverse soil flora and fauna. Cropping sequence and rotations involving legumes helps in minimal rates of build-up of population of pest species, through life cycle disruption, biological nitrogen fixation, control of off-site pollution and enhancing biodiversity (Kassam and Friedrich, 2009; Dumanski *et. al*., 2006).

Source: FAO

1.3.1 Zero Tillage:

In the past agriculture has looked at soil tillage as a main process in the introduction of new crops to an area. It was believed that tilling the soil would increase fertility within the soil through mineralization that takes place in the soil. Also tilling of soil can cause severe erosion and crusting which will lead to a decrease in soil fertility. Today tillage is seen as a way of destroying organic matter that can be provided within the soil cover. No-till farming has caught on as a process that can save soils organic levels for a longer period and still allow the soil to be productive for longer periods (FAO, 2007).

The first, key step in CA is to minimize the disturbance of the soil—no plowing or harrowing is necessary. Seed is planted directly into undisturbed soil along with fertilizer using specialized zero-tillage (ZT) seeders. This eliminates the fuel and labor costs associated with plowing, and reduces emissions of greenhouse gases. Most importantly, by not plowing, crops can be sown immediately after (or before the first autumn rains) which boosts yields. By not disturbing the soil so much, ZT improves soil fertility (organic matter content, physical structure, and water infiltration and storage) and the rates of seed sown can also be reduced, resulting in yet another saving.

Zero tillage minimizes time for establishing a crop. The time required for tillage can also delay timely planting of crops, with subsequent reductions in yield potential (Hobbs & Gupta 2003). By reducing turnaround time to a minimum, zero-tillage can get crops planted on time, and thus increase yields without greater input cost.

1.3.2 Soil cover

Zero-tillage combined with permanent soil cover, has been shown to result in a build-up of organic carbon in the surface layers (Campbell *et al.,* 1996a; Lal, 2005). No-tillage minimizes soil organic matter losses and is a promising strategy to maintain or even increase soil C and N stocks (Bayer *et al.,* 2000).

The second key step in CA is to create a permanent organic soil cover which is synonymous to retention of crop residues (mulch). Mulch can allow for growth of organisms within the soil structure. This growth will break down the mulch that is left on the soil surface. The breaking down of this mulch will produce a high organic matter level which will act as a fertilizer for the soil surface. If the practices of CA were being done for many years and enough organic matter was being built up at the surface, then a layer of mulch would start to form. This layer helps prevent soil erosion from taking place and ruining the soils profile or layout.

Maintaining stubble and other crop residues from the previous harvest on the soil surface and leaving the soil undisturbed protects farmland from wind and water erosion and from the extremes of heat. The occurrence of dust storms is reduced significantly. It also helps increases infiltration of rainfall, reduces runoff, cracking in clay soils, and reduces evaporation of moisture from the soil surface. The stubble and crop residues accumulate in the soil, increasing soil organic matter, improving the soil's structure and sequestering carbon. This boosts the soil's ability to hold water and make it available to plants. Removal or grazing of crop residues from the field is discouraged as this often leaves the soil bare and unprotected. Likewise, burning crop residues makes the soil prone to erosion and valuable nutrients are lost from the system.

1.3.3 Crop rotation

The third principle is the practice of crop rotation with more than two species. Crop rotation can be used best as a disease control against other preferred crops (Hobbs *et al*., 2007). This process will not allow pests such as insects and weeds to be set into a rotation with specific crops. Rotational crops will act as a natural insecticide and herbicide against specific crops. Not allowing insects or weeds to establish a pattern will help to eliminate problems with yield reduction and infestations within fields (FAO, 2007). Crop rotation can also help in building up a soils infrastructure. Establishing crops in a rotation allows for an extensive buildup of rooting zones which will allow for better water infiltration (Hobbs *et al.,* 2007).

It is well known that a lack of crop rotation, or monoculture, leads to a build-up of weeds, diseases and insect pests, and declining yields. Relying on one crop can also be economically risky. The inclusion of legumes in rotations is especially valuable because they boost soil nitrogen levels. Conventional thinking says that plowing and burning crop residues help control weeds, pests, and diseases, but the same or better results can be achieved using crop rotations and judicial use of pesticides. Switching crops each season interrupts the cycle of pests and diseases that build up when the same crop is grown repeatedly, providing the foundation for integrated pest management.

When farmers initially switch to conservation farming, they may need some help from chemicals, especially with weed control, but this is part of learning to manage weeds, pests, and diseases in an integrated way. Continuously growing cereals can lead to high populations of grass weeds, whereas these can easily be controlled in broad-leafed crops like legumes with selective herbicides. Likewise, broad-leafed weeds can be controlled in cereals.

1.4 Features of CA

Conservation agriculture systems require a total paradigm shift from conventional agriculture with regard to management of crops, soil, water, nutrients, weeds, and farm machinery (Sharma *et al.,* 2012). Some of the salient features of conservation agriculture vis- à-vis conventional system are given in Table 1.

Table 1. Salient features of conservation agriculture vis-a-vis conventional system

Features	Conventional agriculture	Conservation agriculture
Cultivation	Ecologically unsustainable	Eco-friendly
Tillage	Excessive mechanical tillage	No- till or reduced tillage(biological tillage)
Crop Residue	Burnt or removed (bare surface) incorporated.	*in-situ* surface retention (permanently covered)
Manuring	No manuring/Green manuring (incorporated)	Brown manuring/cover crops (surface retention)
Crop rotation s	Mono cropping/culture, less efficient rotations	Diversified rotations involving legumes
Farm operatio ns	Heavy reliance on manual labor, uncertainty of operations	Mechanized operations, ensure timeliness of operations. Labour requirements are generally reduced by about 50%. Fuel savings in the order of around 60% or more

Source: sharma et al, 2012

1.5 Major available CA technologies in Bangladesh

• SRI system under permanent raised bed condition

• Unpuddled rice transplanting system by strip and raised bed method

• Strip tillage technology by same crops

• DSR under strip tillage and zero tillage methods

• Zero tillage technology

• Unpuddled zero till rice transplanting system in boro rice season

• Rain water harvesting

• Crop residue incorporation

• Drip/ sprinkle/ gated irrigation

• Mulching- crop residues, paddy straw, green leaves

• Cover crops- Green manuring and Pulse crops

1.6 Justification of the study

In the economic as well as environmental sense this farming system shows improved performance then traditional farming. Reduction in input use may help to get benefits forward by declining the crop production cost. Cover crops may reduce the cost of labor, fertilizer and fuel for subsequent crops. Cover crops also have a positive effect on crop yield. Cover crops like grass and legume can increase in crop yield by an average of 21% (Miguze and Bollero 2005). Crop rotation involving three or more crop has a positive effect on crop yield (Boyle 2006 and Duffy 2012). A properly managed crop rotation is not associated with any yield decrease rather than it has a greatest potential to increase yield. Needless to say that research is necessary to determine the pattern of diffusion of conservation agriculture in order to formulate ling term strategy on crop production. As no research in the field of adoption ofthis technology has been identified so far the deemed it timely necessity to undertake the present study entitled “determinants of adoption conservation agriculture practice in some selected areas of Bangladesh.”.

1.7 Specific objectives:

- To assess the socio economic profile of farmer; and
- To identify the factors affecting the adoption of conservation agriculture

1.8 Limitation of the study

Considering the time, money and other necessary resources available to the researches and to make the study manageable and meaningful, it becomes necessary to impose certain limitation as noted below:

1. Population of the study were kept confined within the heads of the conservation agriculture families as because they are major decision makers in the determination of the adoption of conservation agriculture.
2. Characteristics of the conservation agriculture farmers are many and varied but only few are selected for investigation of this study as stated in the objectives. This was done to complete the study within the limited resources.
3. The was confined mainly to determine the probability of adoption of conservation agriculture.
4. Facts and figures were collected by the investigator applied to the present situation in the selected areas.

CHAPTER TWO
LITERATURE REVIEW

Dhar *et. al.* (2017) conducted a research on Adoption of Conservation Agriculture in Bangladesh: Problems and Prospects. Findings of the research shows that adoption of conservation agriculture practice in the study areas had a colossal impact on farmers' crop profitability. If focal farmers would continue following the principles of this practice, they would be more profitable in terms of crop production compared to control farmers. The study further identified a number of constraints, and internal and external prospects of adopting conservation agriculture in the study areas.

Uddin *et. al.* (2017) performed a research on Conservation Agriculture Practice in Bangladesh: Farmers' Socioeconomic Status and Soil Environment Perspective and concludes that conservation agriculture, as a new resource saving farming practice was appreciated and successfully adopted by the farmers. The study exposed that crop productivity of the farmers adopting conservation agriculture practice increased in response to the crop production in the entire region. It is also revealed that farmers' income was increased through adopting conservation agriculture. Farmers got higher price for their product free from fatal medicine and synthetic fertilizers. This practice helped the farmers to minimize their labour and other input cost. The study also indicates that poverty in terms of deprivation of health, education and living standards was decreased; and overall socioeconomic condition was improved after adopting conservation agriculture practice. Majority of both focal and proximal farmers avowed about enhanced soil environmental circumstances after adopting conservation agriculture than before, while majority of control farmers stated about constant soil environmental condition. A number of factors had significant influence on improving environmental quality due to practicing conservation agriculture. Government input support and agricultural extension services should be properly executed and monitored to promote the practice of conservation agriculture. Also, programmers for motivating and training the farmers should be arranged by different government and non-government organizations to enhance farmers' knowledge on conservation agriculture practice.

Uddin *et. al.* (2016) conducted a research on adoption of conservation agriculture practice in Bangladesh: Impact on crop profitability and productivity and revealed that farmers experienced a great reduction in their cost of production as well as a remarkable increase in crop production. It also states that if the farmers would cultivate crop in entire cropland using conservation agriculture method, it would be profitable compared to the conventional farming practice. The study concludes that conservation agriculture as a new resource saving farming practice was appreciated and successfully adopted by the farmers in the study areas. Farmers were provided limited input support for 10.0 decimal land (command area) to adopt conservation agriculture. The study reveals that with this limited support, farmers experienced a great reduction in their cost of production as well as a remarkable increase in the crop production in that command area. It is also evident from the study that if the farmers in the study areas would cultivate crop in their entire cropland according to this farming practice, it would be profitable compared to conventional farming practice. The study further reveals that crop productivity of the farmers adopting conservation agriculture practice increased in response to the crop production in the entire region.

Akteruzzaman *et. al.* (2012) conducted a research on practices of conservation agriculture technologies in divers cropping system in Bangladesh and found that 39.30% respondents practiced crop rotation and 30% respondents practiced mix cropping and most of them experienced increased production. This study concluded that higher CA practices induced higher cropping intensity and farm income. The widely use of rented power tillers are inducing farmers to adopt CA technologies. CA adopters are practicing diversified tillage operations and among them strip tillage was mostly established. Traditional methods of weeding were also largely practiced in the rice crop field than the other crops (i.e. wheat, maize, jute, pulsed, oilseeds, vegetables and other crops). If these issues are taken into consideration, CA can be adopted more extensively in Bangladesh.

Poddar *et. al.* (2017) did a research on Conservation agriculture: A farm level practice in Bangladesh and stated that farmers are interested practicing CA components like zero tillage, permanent organic soil coverage and crop residues retention. Extension media contact increases the outlook of the farmers to practice CA components effectively and efficiently. The involvement of farmers in diversified organizations help in interacting with other people which might increases practice of CA. It also enhances interaction among the farmers which might influence the efficient use of available resources to adopt CA. If research institutes can develop CA techniques these solve the high weed problem, it will be easy to motivate farmers to use CA. Other problems should be addressed by the concerned extension service providers to improve the practicing of CA.

Hobbs *et. al*. (2007) conducted a research on The role of conservation agriculture in sustainable agriculture and stated that crop production in the next decade will have to produce more food from less land by making more efficient use of natural resources and with minimal impact on the environment. Only by doing this will food production keep pace with demand and the productivity of land be preserved for future generations. This will be a tall order for agricultural scientists, extension personnel and farmers. Use of productive but more sustainable management practices described in this paper can help resolve this problem. Crop and soil management systems that help improve soil health parameters (physical, biological and chemical) and reduce farmer costs are essential. Development of appropriate equipment to allow these systems to be successfully adopted by farmers is a pre- requisite for success. Overcoming traditional mindsets about tillage by promoting farmer experimentation with this technology in a participatory way will help accelerate adoption. Encouraging donors to support this long-term applied research with sustainable funding is also an urgent requirement.

Hossain *et. al.* (2015) performed a research on Status of Conservation Agriculture Based Tillage Technology for Crop Production in Bangladesh and described that farmers accept conservation agriculture based tillage technologies considering the advantages of higher yields, reduced cost of tillage operation, and minimum turnaround time between the crops. Up land crops are more suitable under these tillage technologies. Most of the tillage implements are operated by imported Chinese two-wheel tractor (power tiller). There are few four-wheel tractor CA implement. Minimum tillage seed drill, raised bed planter, zero till drill and strip till drills are being fabricated in different local machinery workshop. Some manufacturers can fabricate implements independently. There are considerable numbers of manufacturers fabricating tillage implement in different districts. Farmers started adopt the CA technologies, especially raised bed planting and minimum tillage technology. Weed management in rice cultivation is not yet in a good shape. Herbicide availability and proper using technique of those herbicides are still a problem. There is a big prospect accelerating the CA based tillage technology in the farmers' field as irrigation water availability becoming limited or costlier. Mind set up is the big issue for adopting CA tillage technology. Training and multi-disciplinary approaches can push forward these tillage technologies ahead.

Ngwira *et. al.* (2014) did a research on Adoption and extent of conservation agriculture practices among smallholder farmers in Malawi and suggested that membership to farmer groups, resource endowment (hired labor and total land cultivated), and district play an important role in shaping adoption and extent of CA, presenting a unique set of challenges for farmers in this region. Membership to an NGO group appeared the most important factor influencing adoption and extent of CA. Public extension workers remain the prime agents of promoting agricultural technologies in Malawi and the study results reveal that these change agents are not provided with adequate resources necessary to facilitate CA adoption. In absence of NGO support in facilitating farmers' access to key agricultural inputs, there is need to encourage participation of local agro dealers in providing inputs and information that are necessary for farmers practicing CA. Government extension staff should be fully supported in terms of resources to enable them reach a wider audience of smallholder farmers if extensive adoption of CA is to be realized. Hence, without proper farmer training and group formation, farmers are likely to experience slow adoption of CA.

Nyanga *et. al.* (2012) conducted a research on Factors Influencing Adoption and Area under Conservation Agriculture: A Mixed Methods Approach and showed that both quantitative and qualitative factors influence the adoption of CA. Quantitative analysis indicated that CA trainings, previous experience with minimum tillage, membership in farmer organizations, and ownership of CA tillage equipment increased the likelihood of CA adoption significantly. Quantitative approaches further indicated that increase in number of CA trainings attended, farm size and number of rippers owned and use of herbicides had a positive significant influence on area under CA. Qualitative approaches showed that good rapport with farmers, trust, reciprocity and altruism, monitoring and evaluations, extension strategy, quality and extent of technical knowledge in CA, and artificial incentives positively influenced the adoption of CA. Traditional leadership was reported to enhance adoption of CA in most cases. Prestige was reported to withhold some men from adopting CA basins. Women were mostly involved in CA basins while men were mostly involved in ADP ripping. Some worldviews of farmers had negative influence on adoption of CA. Donor support and collaboration with the Zambia National Farmers Union and the private sector were other contextual factors for the high adoption of CA among sampled smallholder farmers.

Pannell *et. al*. (2013) performed a research on The farm-level economics of conservation agriculture for resource-poor farmers and stated that Conservation Agriculture has potential to contribute to the welfare of farmers in developing countries. However, not all circumstances are the right circumstances. It is also possible for CA to be economically unattractive to farmers because its benefits (broadly defined) are not sufficient to outweigh its costs (broadly defined), considering the specific farming context, risk and uncertainty, learning costs, constraints on key resources such as labor and capital, interactions between enterprises, and time-related factors. Therefore, economic analysis helps to explain the adoption and non-adoption of CA as a package. It also provides insights into why farmers often adopt the elements of packages like CA in a selective, partial way, or do so step-wise over a period of time. Findings of the paper indicate that agricultural research and extension organizations should avoid promoting CA as a one-size-fits-all solution to the economic and natural resource challenges that farmers face. Such an approach is bound to waste agency and farmer resources in those circumstances where CA is not economically attractive to farmers. A more productive approach is to recognize the heterogeneity of farming circumstances, and make efforts to identify (including by economic analysis) those cases where CA, or one or more of its components, are adoptable. Efforts to promote CA should be focused on those cases.

Knowler *et. al*. (2007) did a research on Farmers' adoption of conservation agriculture: A review and synthesis of recent research and described that Conventional agricultural practices, and especially the deep tilling of soils, have increasingly been seen as problematic by those concerned with the health of agroecosystems and ultimately global food security. In response, the concept of conservation agriculture has been developed to aggregate a number of related soil management and conservation techniques under a single banner for purposes of promotion and analysis. While the concept may be novel, many of its associated techniques have been previously investigated by researchers. It has been the intent to pull together these disparate research efforts in order to assess the progress made thus far by social scientists to understand the farm-level adoption of conservation agriculture, with the ultimate aim of offering refined policy prescriptions for augmenting adoption.

Ghatala *et. al.* (2014) described in his research paper Adoption of conservation agriculture technology in diversified systems and impact on productivity: evidence from three districts in Bangladesh that Conservation tillage technologies reduce soil disturbances and are more environmentally friendly. they applied double hurdle model to examine the probability and intensity of adoption of conservation tillage technologies promoted under participatory on-farm trials in an intervention project on "Sustainable intensification of Rice-Maize (R-M) production systems in Bangladesh". The participatory farmers extended the technologies to their own plots. The econometric analysis reveals that the probability of CA expansion is higher in land having the characteristics of sandy soil. Also farmers with more plots and have access to income from some non-farm sources are likely to adopt CA. The likelihood of adoption differs between cropping patterns, climatic conditions and irrigation access. The likelihood of adoption is constrained by rental market and intensity of adoption is constrained by soil type.

It is often argued that crop yields may fall in the initial phases of CA adoption, and will only rise above conventional tillage figures when the CA system has stabilized. In this study they realized that CA can produce equivalent or higher yields compared to conventional tillage systems, particularly in Rabi maize and Kharif2 rice. While soil health, water savings etc are important to long run societal well-being, reliable and significant increases in crop yield offer an immediate and tangible benefit to individual farmers.

The literature review mentioned indicates that most of the research dealt with either crop productivity or profitability in conservation agriculture practice. To minimize the research gap, this study would be helpful at evaluating the probability of adoption of conservation agriculture practice on the socioeconomic issues on enhancement of the livelihood of the farmers along with the factors that affect the adoption of conservation agriculture. Research plan of policy and implementation modality gap to identify the successful technology of appropriate farm machinery project for regional development of CA and policy intervention mechanism of conservation agriculture in Bangladesh.

CHAPTER THREE

METHODOLOGY

Methodology deserves a very careful consideration in conducting scientific research. Importance of methodology in conducting any research cannot be undermined. Methodology enables the researcher to collect valid and reliable information and to analyze them properly to arrive at correct decisions. Keeping this point in view, the researcher took utmost care for using proper methods in all the aspects of this piece of research work. Methods and procedures followed in conducting this study has been described in this chapter.

3.1 The Locale of the study

Kakonhat and Dharabarisha unions of Godagari and Gurudashpur Upazilla under Rajshshi and Natore district was purposefully selected due to easy communication as well as easy contact with the farmers who practices or not practices CA practices and technologies. This Godagari Upazila is situated at about 26.4 Km from Rajshshi town and Gurudashpur Upazila is situated at about 41.2 km from Natore town. According to the guidance of the research supervisory committee two Union with CA as the more cultivated crop were to be the study area of the present research. Six villages were selected randomly by taking two from each selected unions. Thus, Dorgapara, Joykrishnopur, Brammon Nagar were selected from Godagari Upazila of Rajshahi district and Sidhuli, Cholonali and Chorkadoho were selected from Gurudashpur Upazila of Natore district. Showing the study area have been presented in figure 3.1 and 3.2 for Godagari Upazila in Rajshahi district and 3.3 and 3.4 for Gurudashpur Upazila in Natore district respectively.

Figure 3.1 A map of Rajshahi district showing Godagari Upazila

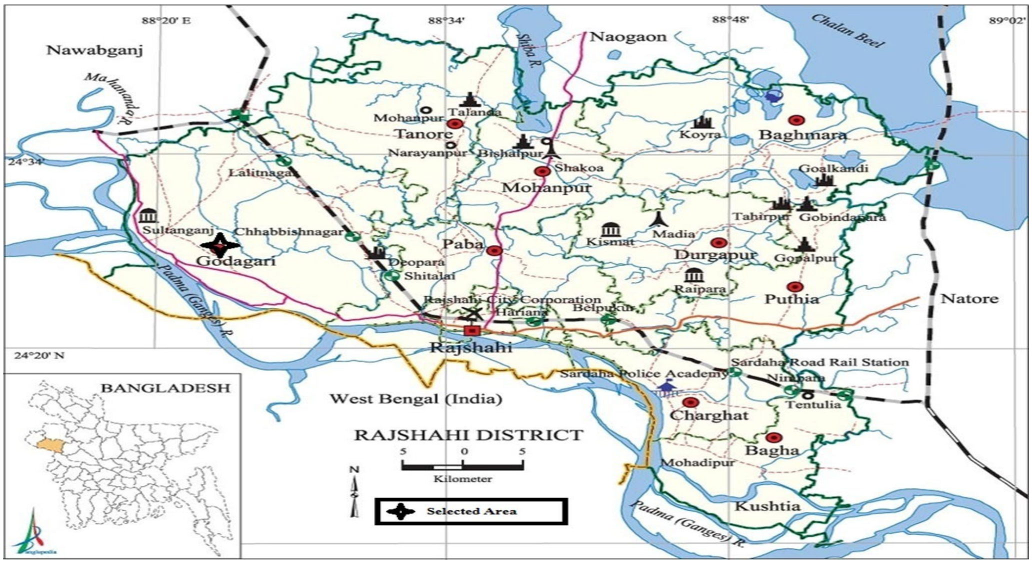


Figure 3.2: A map Godagari Upazila showing kakonhat union

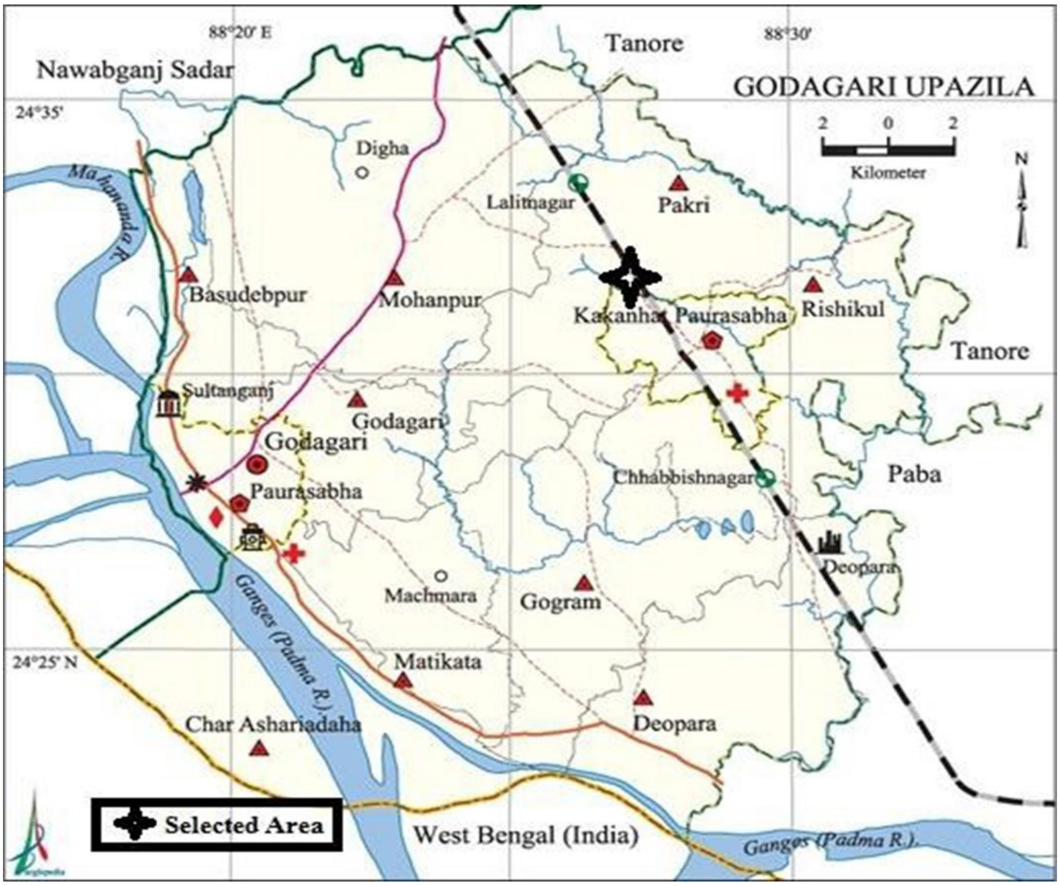


Figure 3.3 A map of Natore district showing Gurudashpur upazila

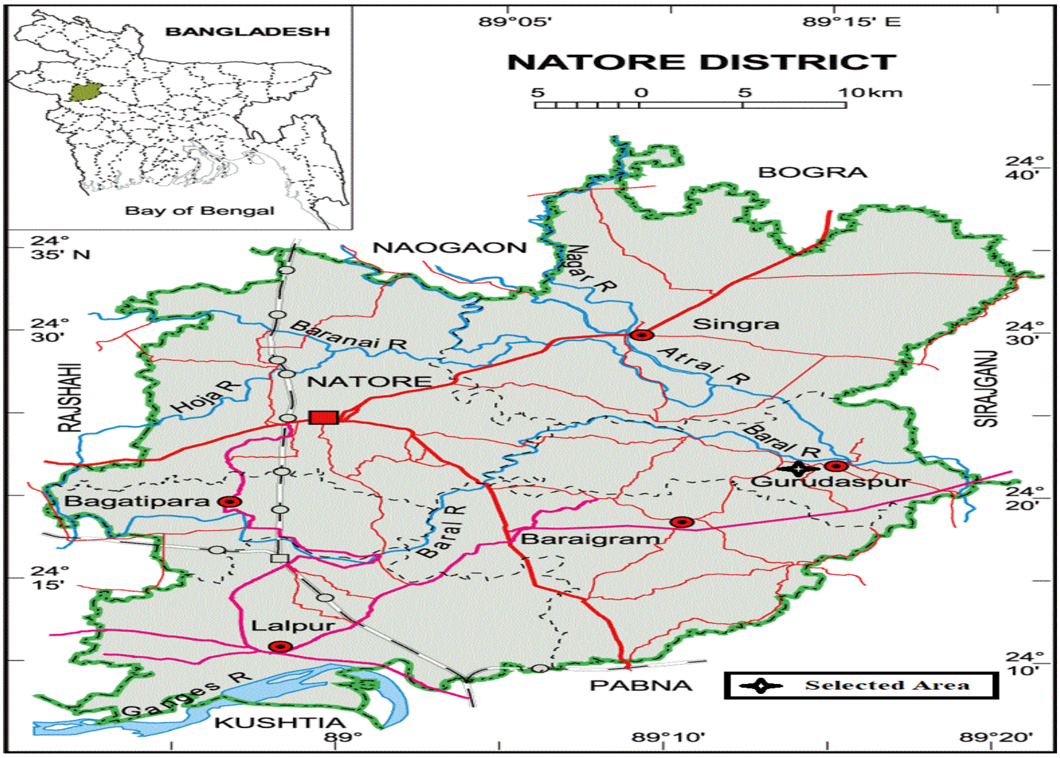
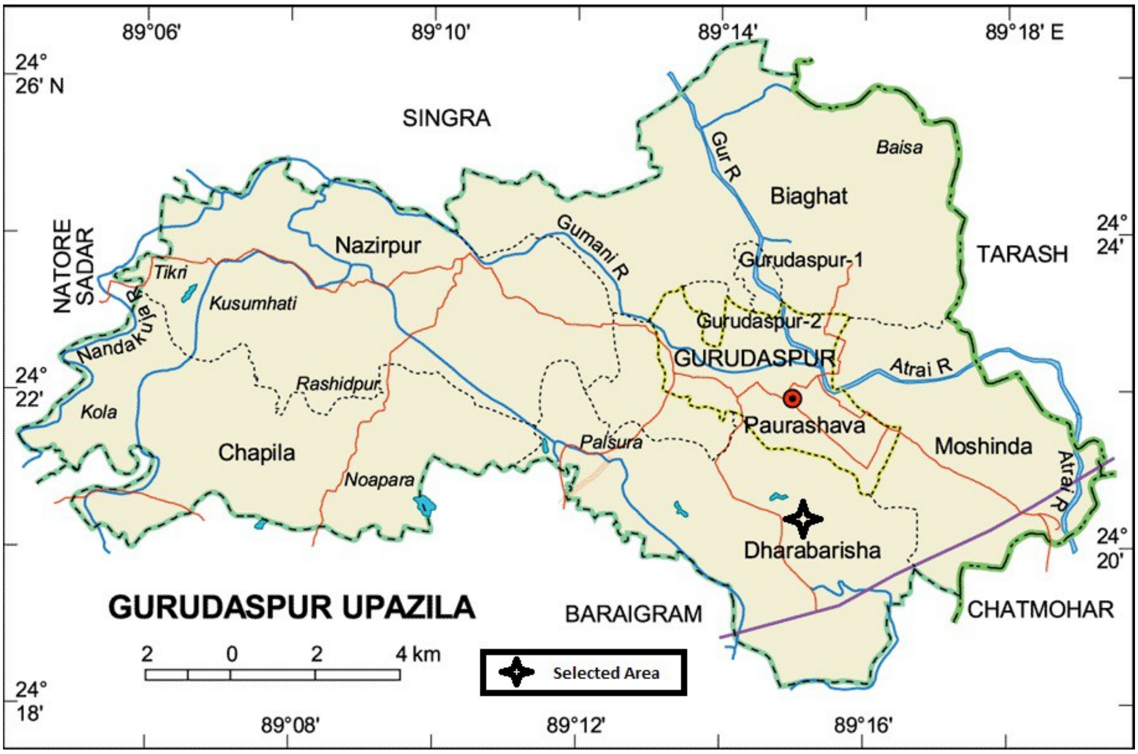


Figure 3.4: A map of Gurudashpur showing Dharabarisha union



3.2 Population and sampling design

The farmers of the selected villages were the population of the study. Six separated villages (three from Godagari upazila and three from Gurudashpur upazila) selected randomly to identify CA practicing farmers. List of the farmers of the selected villages were prepared with the help of Sub Assistant Agriculture Officer and Upazila Agricultural officer of Godagari Upazila and Gurudashpur Upazila in Rajshshi and Natore district respectively. The population size was 200 which was selected randomly from these six villages. Half of the populations were selected randomly from each village as the sample of the study. From that sample size it is found that 64 farmers are practicing CA technologies and 36 farmers are not practicing CA technologies. If anyone included in the original sample were unavailable during data collection, the next farmers regarding that list were considered turn by turn for collecting data. The distribution of populations, sample and reserve list are shown in Table 3.1.

Table 3.2.1 Distribution of populations and sample

District	Upazila	Village	Sample Size	Population
Rajshahi	Godagari	Dorgapara	20	50
		Joykrishnopur	22	44
		Brammon Nagar	8	16
Natore	Gurudashpur	Sidhuli	25	50
		Cholonali	15	30
		Chorkadoho	10	20
Total			**100**	**200**

3.3 Instruments for data collection

In order to collect reliable and valid Information from the CA farmers, an interview schedule was prepared carefully keeping the objectives of the study in mind. The interview schedule contained both open and closed form questions.

Appropriate schedule was also developed to operationalize the selected characteristics of the CA farmers. The draft interview schedule was prepared in english version and was pre-tested with CA farmers. This pre-test facilitated the researcher to examine the suitability of different questions and statements in general. The interview schedule has been shown at Appendix-A.

3.4 Measurement of Variable

A variable is any characteristic, which can assume varying, or different values in successive individual cases (Ezekiel and Fox, 1959). An organized research usually contains at least two important variables, viz. an independent and a dependent variable. An independent variable is that factor which is maintained by the researcher in his attempt to ascertain its relationship to an observed phenomenon. A dependent variable is that factor which appears, disappears or varies as the researcher introduces, removes or varies the independent variable (Townsend, 1953). The independent variables of the study were nine selected characteristics of the CA growers. These were, age, education, farm size, training received, farmers experience, family size, access to credit, IPM practices, annual income, severity of extreme. The procedures followed in measuring the independent variables are briefly discussed below:

3.4.1 Age

In the study, all categories of farmers of the study area were classified into different age groups. First age group ranges between 21-30 years, second age group ranges from 31-40 years, third group ranges between 41-50, fourth age group ranges between 51-60 and the last group were selected who are more than 60 years. This variable appears in the interview schedule as presented in Appendix-A.

3.4.2 Education

Education was measured in terms of successful years of schooling. Education for all farmers were categorize into four groups. First group indicated primary education (1-5), second group represent high school or secondary school (6- 10) and third group refers higher secondary (11-12) and fourth group represents more than higher secondary education. This variable appears in the interview schedule as presented in Appendix-A.

3.4.3 Farm size

The farm size of a CA farmer referred to the total area of land, on which his family carried out farming operations, in terms of full benefit to his family. The farm size was measured in hectares for each CA farmers using the following formula:

The data were first recorded in term of local unit i.e. bigha and then converted to hectare. Total farm size of each respondent was categorized into 5 types (Islam, 2007). The farmers who had land bellow 0.02 hectare were considered as landless farmer. The farmers who had land between 0.02-.20 hectare were considered as marginal farmers; the farmers who had the land between 0.2-1.00 hectare were considered as small farmers; the farmers who had land between 1.01-3.0 hectare of land considered as medium farmers and above 3 hectare considered as large farmers. This variable appears in the interview schedule as presented in Appendix-A.

3.4.4 Training received

In the study, all categories of farmers of the study area were classified into different training receive group. The first group indicated lower training received group (less than 4 days), second group were medium training received group (5-7 days) and last group of training receive group is high training receive group (above 8 days). This variable appears in the interview schedule as presented in Appendix-A.

3.4.5 Severity of drought events

In this study, severity of drought event was classified into different category namely extreme severe (4), moderate severe (3), low severe (1) and lastly none for zero. This variable appears in the interview schedule as presented in Appendix-A.

3.4.6 Access to agriculture related credit

This independent variable is categorized into only two types. The farmers who receive agriculture related credit were defined yes and on the other hand the farmers who didn't receive any agriculture related credit mentioned it no. This variable appears in the interview schedule as presented in Appendix-A.

3.4.7 Total experience of the farmers

In this study, total experience of farmers was categorized into different experienced group. The first group namely lower experienced group (less than 20 years), second group indicated medium experienced group (21-30 years), high experienced group (31-40) and lastly very high experience group (more than 40 years). This variable appears in the interview schedule as presented in Appendix-A.

3.4.8 IPM practices

This independent variable is categorized into two different group. The first group were the farmers who were practicing IPM is indicated by (1) and the farmers who didn't practicing IPM mentioned it by (0). This variable appears in the interview schedule as presented in Appendix-A.

3.4.9 Total annual income of the farmers

In this study, the annual income of farmers is divided into different categorized. The first category was the group of farmers whose annual income is less than 50000 tk, second category referred the farmers group whose income is ranges from 51000-250000 tk and the last group were categorized into the group of farmers whose income is more than 251000 tk. This variable appears in the interview schedule as presented in Appendix-A.

3.5 Statement of the Hypotheses

In order to guide relevant data collection, analysis and interpretation of data, a set of hypothesis would be formulated for empirical testing. As defined by Goode and Hatt(1952), "Hypothesis is a proposition which can be put to test to determine its validity. It may seem contrary to, in accord with common sense. It may prove to be correct or incorrect. In any event, however, it leads to an empirical test." In broad sense, hypothesis may be divided into two categories, namely, research hypothesis (H1) and null hypothesis (H0). In studying relationships between variables an investigator first formulates research hypothesis which states anticipated relationships between the variables. On the other hand, for statistical test, it becomes necessary to formulate null hypothesis. A null hypothesis states that there is no contribution with the concerned variables. The following null hypothesis would be formulated to explore the relationship of the selected characteristics of the growers with their adoption of CA. There is no significant contribution with the selected characteristics of the growers and their adoption of CA.

H_0: There is no contribution of independent variables in CA adoption

$H_{a:}$ There is a contribution of independent variables in CA adoption

3.6 Collection of Data

The researcher himself collected data from the CA farmers by using the interview schedule. The interviews were conducted individually in the houses of the respondents during their leisure period. Only ten CA farmers of the original list were not available during interview and hence ten CA farmers were replaced from the reserve list. Prior information was given to the respondents before going to them for interviewing. The researcher took all possible care to establish rapport with them. While any respondent faced difficulty in understanding any question, the researcher took utmost care to explain the issue. He obtained excellent cooperation from the respondents and others concerned during the time of interview. The entire process of collecting data took 07 days from September 12 to September 20, 2020.

3.7 Data Processing

A detail coding plan was prepared. Data were coded into a coding sheet. These were then compiled, analyzed in accordance with the objectives of the study. Qualitative data were converted into quantitative form by means of suitable scoring techniques for the purpose of analysis.

3.8 Statistical Analysis

The analysis was performed using Statistical Package for Social Sciences (SPSS V 20) computer package and STATA. Descriptive analyses such as range, number, percentage, mean, standard deviation were used whenever possible. To find out the contribution of identified characteristics of the conservation agriculture farmers, probit model was used. Throughout the study, five percent (0.05) level of probability was used as basis of rejecting a null hypothesis.

Analytical techniques

Probit model: In order to ascertain the relationship between the adoption of conservation agriculture practice and socio-economic factors, the following empirical Probit model (equation 1) was carried out. The dependent variable of this model was adoption of conservation agriculture practice.

$Y_i = \alpha + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + \beta_4 X_4 + \beta_5 X_5 + \beta_6 X_6 + U_i$,

Where

Y_i = Adoption of Conservation Agriculture

α = Intercept

X_1= age

X_2= education

X_3= farm size

X_4= training on CA

X_5= experience

X_6= drought events

U_i= error term

CHAPTER FOUR

RESULT AND DISCUSSION

4.1 Socio-economic analysis

4.1.1 Age distribution

In the study, all categories of farmers of the study area were classified into different age groups as presented in Table 4.1.1. It is evident from the table that most of the farmers were middle aged in the study area. Out of the 64 sample farmers 1.6 % belonged to the age group of 21-30 years,

17.2 % belonged to the age group of 31-40 years, 48.4 % fell into the age group of 41-50 years, 31.3 % fell into the group of 51-60 years, and 1.6 % above 60 for adaptor of CA practices. And out of total 36 sample farmers 2.8 % belonged to the group of 21-30 years, 30.6 %belonged to the group of 31-40 years, 30.6 percentage fell into the age group of 41-50, 30.6 % fell into the group of 51-60 years and 5.6 % above 60 years old. This finding imply that majority of the sample farmers were in the most active age group of 31-60 years indicating that they provided more physical efforts for farming. Again the age distribution of the farmers scores ranged from 20 to more than 60 with a mean and standard deviation for CA adaptor is 4.14 and .774, for non-adaptor mean and standard deviation is 4.06 & .984 respectively.

Table 4.1.1: Age distribution

Age group	Adopter		Non adopter	
	Frequency	Percentage	Frequency	Percentage
21-30 Years	1	1.6	1	2.8
31-40 Years	11	17.2	11	30.6
41-50 Years	31	48.4	11	30.6
51-60 Years	20	31.3	11	30.6
Older than 60 Years	1	1.6	2	5.6
Total	64	100	36	100.0
Mean	4.14		4.06	
Std. deviation	.774		.984	

Source: Field survey, 2020

4.1.2 Educational status

Education increases the efficiency of man. Education of farmers helps to adopt due to climate change. Bangladesh it has, an adult literacy rate of 70.20% (BBS, 2019). Table 4.1.2 shows for CA adaptor, 9.4 percent farmers had primary education, 84.4 percent farmers had completed secondary level education, 4.7 percent farmers had completed their higher secondary level education and 1.6 percent studied more than higher secondary level. And for non-adaptor 11.1 percent farmers had primary education, 80.6 percent farmers had completed secondary level education, 5.6 percent farmers had completed their higher secondary level education and 2.8 percent studied more than higher secondary level. Literacy status is good at the study area compared to the national level literacy status. Again the education level of the farmers scores ranged from 0 to More than 12 with a mean and standard deviation for CA adaptor is 1.98 and 0.454, for non-adaptor mean and standard deviation is 2.00 & 0.535 respectively.

Table 4.1.2: Educational level distribution

Education level	Adopter		Non adopter	
	Frequency	Percentage	Frequency	Percentage
Primary	6	9.4	4	11.1
Secondary	54	84.4	29	80.6
Higher Secondary	3	4.7	2	5.6
Greater than Higher Secondary	1	1.6	1	2.8
Total	64	100.0	36	100.0
Mean	1.98		2.00	
Std. Deviation	.454		.535	

Source: field survey, 2020

4.1.3 Farmers experience in Agriculture

In the study, all categories of farmers of the study area were classified into different experience groups as presented in table 4.1.3. It is evident from the table that most of the farmers were medium experienced family in the study area. Out of the 64 sample farmers 21.9 percent belonged to the group of lower experienced, 50 percent belonged to the group of Medium experienced, 25 percent fell into the group of high experienced group and 3.1 percentage fell into the very high experienced group for adaptor of CA practices. Out of total 36 sample farmers 27.8 percentage belonged to the group of lower experienced, 38.9 percentage belonged to the group of medium experienced, 22.2 percentage fell into the age group of high experienced group and 11.1 percentage fell into the very high experienced group for non-adopter on CA practices. This finding imply that majority of the sample farmers were medium experienced. Again the total experience in agriculture distribution of the farmers scores ranged from less than 20 to More than 31 with a mean and standard deviation for CA adaptor is 2.09 and 0.771, for non-adaptor mean and standard deviation is 2.17 and 0.971 respectively.

Table 4.1.3: Total experience in agriculture

Experience group of agriculture	Adopter		Non adopter	
	Frequency	Percentage	Frequency	Percentage
Lower experience (<20 yrs)	14	21.9	10	27.8
Medium experience (21-30yrs)	32	50.0	14	38.9
High experience (31-40yrs)	16	25.0	8	22.2
Very high experience (>40yrs)	2	3.1	4	11.1
Total	64	100.0	36	100.0
Mean	2.09		2.17	
Std. Deviation	.771		.971	

Field survey, 2020

4.1.4 Farm Size

Table 4.1.4 indicates that for CA adaptor the small farm holder constitutes the highest proportion 53.1 percent followed by medium farm holder 39.1 percent, whereas 7.8 percent was large farm holder. Again for CA non-adaptor the small farm holder constitute the highest proportion 77.8 percent followed by medium farm holder 13.9 percent whereas 5.6 percent was large farmer. The findings of the study reveal that majority of the CA farmers were small to medium sized farm holder. Again the farm size distribution of the farmers scores ranged from 0.02 to more than above 3 with a mean and standard deviation for CA adaptor is 3.5469 and 0.64, for non-adaptor mean and standard deviation is 3.22 & 0.591 respectively. This finding also indicates the farmer with marginal farm size has very little scope to experiment about new technologies as their earnings depend on mainly in agriculture.

Table 4.1.4: farm size distribution

Farmers group	Adopter		Non adopter	
	Frequency	Percentage	Frequency	Percentage
Marginal farmers	0	0	1	2.8
Small farmers	34	53.1	28	77.8
Medium farmers	25	39.1	5	13.9
Large farmers	5	7.8	2	5.6
Total	64	100.0	36	100.0
Mean	3.5469		3.22	
Std. Deviation	.64068		.591	

Source: field survey, 2020

4.1.5 Annual income status

Almost 20.80 percent of the population live in poverty, and 10.30 percent of the population live in extreme poverty (BBS, 2020). The $1.90/person/day Purchasing Power Parity (PPP) line is the current definition of extreme poverty (World Bank, 2011). For CA adaptor it is evident from the table 4.1.5 that 17.2 percent farmers are belonged to the middle income group, which indicates that their yearly income lies between Tk. 57000 to Tk. 250000. Most of the farmer's yearly income belonged to the above Tk. 250000 and it is 77.6%. It refers that most of the farmers were well sufficient by following conservation agriculture practices. On the other hand, for CA non-adaptor table 4.1.5 also shows 44.4% farmers were in the poor income category which means that their income is less than 56000. Again remaining 22.3% were above Tk. 250000. So from this we can conclude that the farmers who practicing conservation agriculture are more advanced and sufficient than farmers who weren't practicing conservation agriculture.

Table 4.1.5: Income distribution

Income group (TK)	Adopter		Non adopter	
	Frequency	Percentage	Frequency	Percentage
Less than 56000	6	5.2	16	44.4
57000-250000	11	17.2	12	33.3
More than 251000	47	77.6	8	22.3
Total	64	100.0	36	100.0
Mean	2.83		2.7778	
Std. Deviation	.380		.42164	

Source: field survey, 2020

4.1.6 Knowledge on CA Practice

The score of the knowledge on conservation agriculture ranged from 0 to more than 1.5 with a mean and standard deviation of 3.609 and 0.49 for CA adaptor where for CA non-adaptor the mean and standard deviation for 3.36 and 0.54 respectively. On the basis of knowledge on conservation agriculture farmers were classified into four categories such as, poor knowledge, medium knowledge, high knowledge and very high knowledge on conservation agriculture. The distribution of the farmers according to their knowledge on conservation agriculture scores is shown in the table 4.1.6. Findings shown that for CA adaptor has maximum very high knowledge 60.9% where for CA non-adaptor has high knowledge 58.3 percent.

Table 4.1.6: knowledge level

Knowledge group	Adopter		Non adopter	
	Frequency	Percentage	Frequency	Percentage
Poor knowledge	0	0	0	0
Medium knowledge	0	0	1	2.8
High knowledge	25	39.1	21	58.3
Very high knowledge	39	60.9	14	38.9
Total	64	100.0	36	100.0
Mean	3.6094		3.3611	
Std. Deviation	.49175		.54263	

4.2 Farmers Perception on conservation agriculture

4.2.1 Farmers Perception on Improve Productivity

The observed perception scores of the respondents ranged from 1 to 5. The mean scores were 4.82 with the standard deviation of 0.386. Based on their perception, the respondents were classified into five categories namely strongly agree, agree, no opinion, disagree, strongly disagree. The distribution of the farmers according to their perception shown in the Figure no 4.2.1 that shows 82% of farmers strongly agree that CA practices improve productivity.

Figure 4.2.1: Farmer's perception on Improve Productivity

4.2.2 Farmers perception on reduction of pesticide application cost

The observed perception scores of the respondents ranged from 1 to 5. The mean scores were 3.94 with the standard deviation of 0.736. Based on their perception, the respondents were classified into five categories namely strongly agree, agree, no opinion, disagree, strongly disagree. The distribution of the farmers according to their perception shown in the Figure no 4.2.2 that shows 22% of farmers strongly agree that CA practices reduce pesticide application cost, 52% agree that CA practices reduce pesticide application cost, 24% has no opinion and only 2% disagree with that perception. From this observation we can sate that CA practices helps to reduces the pesticide application cost thus the farmers can mitigate the production cost.

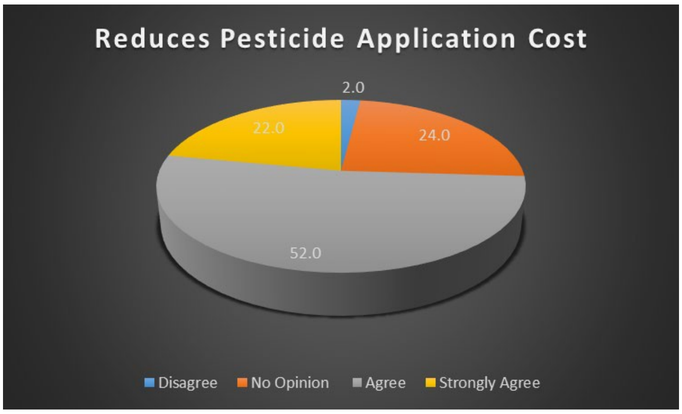


Figure 4.2.2: Farmers perception on pesticide application cost.

4.2.3 Farmers perception on labor intensity of conservation agriculture

The observed perception scores of the respondents ranged from 1 to 5. The mean scores were 2.16 with the standard deviation of 0.368. Based on their perception, the respondents were classified into five categories namely strongly agree, agree, no opinion, disagree, strongly disagree. The distribution of the farmers according to their perception shown in the Figure no 4.2.3 that shows 84% of farmers disagree that CA technologies are labor intensive.

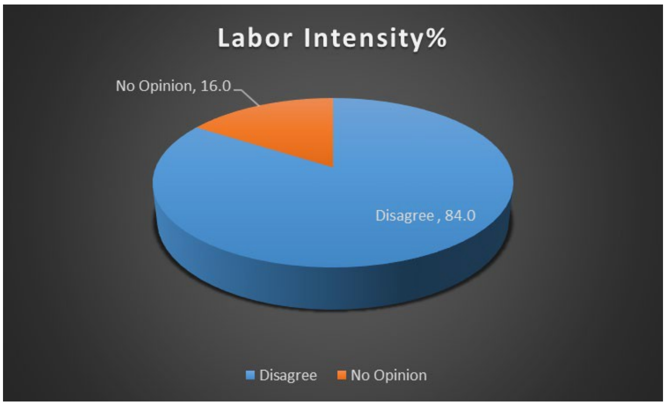


Figure 4.2.3: Farmers perception on labor intensity of conservation agriculture

4.2.4 Farmers perception on Skills Requirement

The observed perception scores of the respondents ranged from 1 to 5. The mean scores were 1.49 with the standard deviation of 0.522. Based on their perception, the respondents were classified into five categories namely strongly agree, agree, no opinion, disagree, strongly disagree. The distribution of the farmers according to their perception shown in the Figure no 4.2.4 that shows 52% of farmers strongly disagree that CA technologies required special skills, 47% stated that they are disagree with this perception.

Figure 4.2.4: Farmers perception on skills requirement

4.2.5 Farmers perception soil structure improvement

The observed perception scores of the respondents ranged from 1 to 5. The mean scores were 4.60 with the standard deviation of 0.532. Based on their perception, the respondents were classified into five categories namely strongly agree, agree, no opinion, disagree, strongly disagree. The distribution of the farmers according to their perception shown in the Figure no 4.2.5 that shows 62% of farmers strongly agree that CA technologies improve soil structure, protects the soil erosion and nutrients losses., 36% agree with this perception and 2% have no opinion.

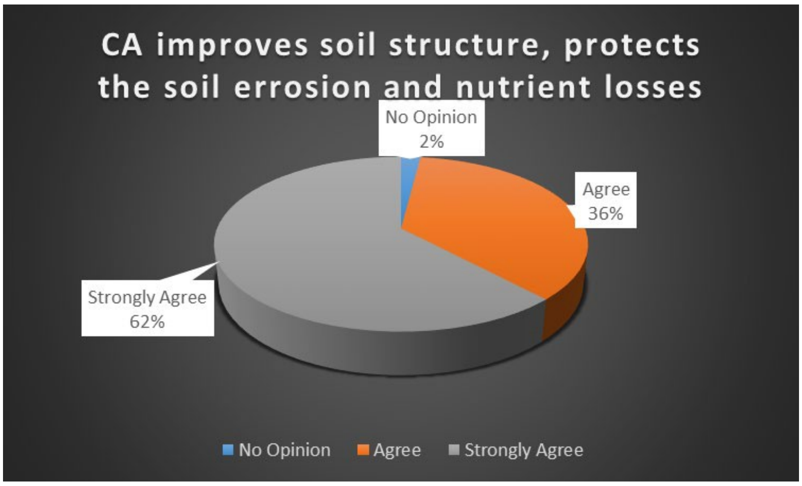


Figure 4.2.5: Farmer's perception on improvement of soil structure

4.2.6 Farmers perception on reduced soil erosion

The observed perception scores of the respondents ranged from 1 to 5. The mean scores were 4.63 with the standard deviation of 0.506. Based on their perception, the respondents were classified into five categories namely strongly agree, agree, no opinion, disagree, strongly disagree. The distribution of the farmers according to their perception shown in the Figure no 4.2.6 that shows 64% of farmers strongly agree that CA technologies protects soil surface from erosion, 35% agree with this perception and 1% have no opinion.

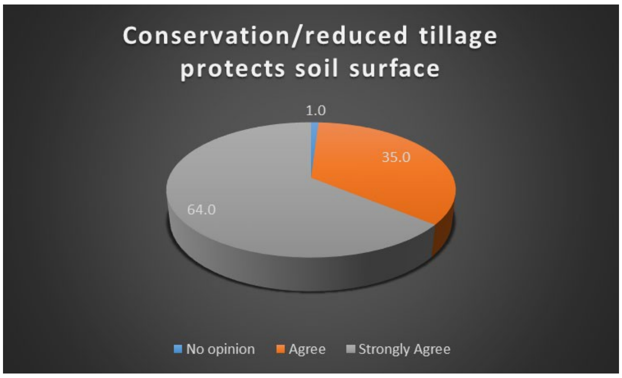


Figure 4.2.6: Farmers perception on pesticide application cost.

4.2.7 Farmers perception on CA technologies protects soil from moisture and limited weed growth

The observed perception scores of the respondents ranged from 1 to 5. The mean scores were 4.79 with the standard deviation of 0.433. Based on their perception, the respondents were classified into five categories namely strongly agree, agree, no opinion, disagree, strongly disagree. The distribution of the farmers according to their perception shown in the Figure no 4.2.7 that shows 80% of farmers strongly agree that CA technologies protects soil from moisture and limited weed growth, 19% agree with this perception and 1% have no opinion.

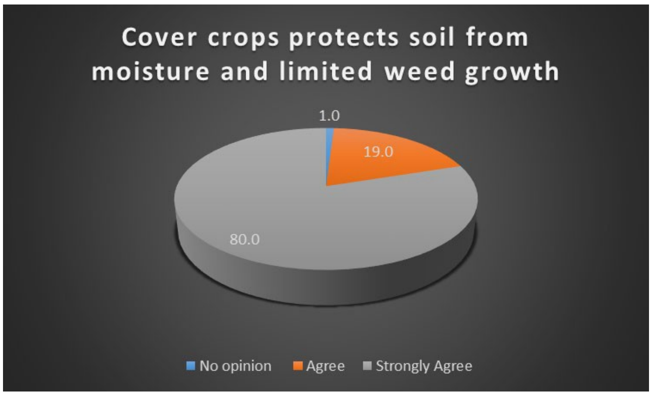


Figure 4.2.7: Farmer's perception on CA technologies protects soil from moisture and limited weed growth

4.3 Factors influencing the adoption of CA technologies

In the study we would like to determine the factors which affect the adoption probability of CA technologies. A probit model was used bringing the determinants influencing adoption probability of conservation agriculture practice. In this model six explanatory variables such as age, education, farm size, training on CA, experience and drought events were identified as major factors for CA adoption.

$Zi = 2.11026 - 0.00043X_1 - 0.023X_2 + 0.644X_3 + 0.059X_4 - 0.022X_5 - 1.296X_6$

Here

X_1= age

X_2= education

X_3= farm size

X_4= training on CA

X_5= experience

X_6= drought events

Three out of six explanatory variables included in the model were found significant in explaining the variation in adoption probability. These variables were farm size, training on Ca and drought events (Table 4.3.1).

Table 4.3.1 Factors influencing the adoption of CA technologies

CA_adoption	Coef.	Std. Err.	z	P>|z|	[95% Conf.	Interval]
Age	**-.0004288**	**.0363643**	**-0.01**	**0.991**	**-.0717016**	**.070844**
Education	**-.0228451**	**.0969881**	**-0.24**	**0.814**	**-.2129381**	**.167248**
Farm_size	**.6444952**	**.2740311**	**2.35**	**0.019**	**.1074042**	**1.181586**
Training_on_CA	**.0589577**	**.0201036**	**2.93**	**0.003**	**.0195554**	**.09836**
Experience	**-.0219243**	**.0366552**	**-0.60**	**0.550**	**-.0937671**	**.0499185**
Drought_event	**-1.296306**	**.3876718**	**-3.34**	**0.001**	**-2.056129**	**-.5364834**
_cons	**2.11026**	**1.648843**	**1.28**	**0.201**	**-1.121413**	**5.341933**

Significant at 5% probability level

From the above table we see that the P value for the variables farm size, training on CA and drought events are 0.019, 0.003 and 0.001 respectively which is less than 0.05. That means farm size, training on CA and drought events are statistically significant at 5% level of significance. That means we will reject the null hypothesis for farm size, training on CA and drought events. This interpretation indicates that farm size, training on CA and drought events has a contribution for adoption of CA technologies. Marginal effect was computed differently for discrete (i.e., categorical) and continuous variables.

Marginal effect measured discrete change i.e., how predicted probabilities were changed due to change in binary independent variable from 0 to 1. Marginal effects for continuous variables measured the instantaneous rate of change (Table 4.3.2).

Table 4.3.2: Marginal effect of different variable

Variable	dy/dx	Std. Err.	z	P>|z|	[95%	C.I.]	X
Age	**-.000159**	**.01349**	**-0.01**	**0.991**	**-.02659**	**.026272**	**46.51**
Education	**-.0084719**	**.03596**	**-0.24**	**0.814**	**-.078949**	**.062005**	**8.35**
Farm size	**.2390063**	**.10136**	**2.36**	**0.018**	**.040336**	**.437677**	**1.10513**
Training on CA	**.021864**	**.00761**	**2.87**	**0.004**	**.006953**	**.036775**	**16.07**
Experience	**-.0081305**	**.01358**	**-0.60**	**0.549**	**-.034755**	**.018494**	**27.84**
Drought events	**-.4807256**	**.14706**	**-3.27**	**0.001**	**-.76895**	**-.192502**	**1.98**

Significant at 5% probability level

The result of marginal effect shows that age had a negative value of dy/dx and it was -0.00015. It indicates that one-year increase in age would decrease the probability of adoption of CA practices by 0.015%. That means as a new farming technique conservation agriculture ismore popular in young generation than older people.

The education had a negative value of dy/dx and it was -0.008. It indicates that the one-year increase in education level would decrease the probability of adoption of CA practices by 0.8%. That means the educated persons are less fond of practicing CA practices than uneducated people.

The farm size had a positive value of dy/dx which was 0.023 and statistically significant at 5% probability level. It indicates that one-unit increase in farm size would increase the probability of adoption of CA practices by 2.3%. It meant that for bigger farm size, the probability of adoption of CA technologies is 0.023 times higher than the small farm size compared to not practicing it. This reason was that the small farmers are relatively laggards for new farming practice.

Training on CA had a positive value of dy/dx and it was 0.021 and statistically significant at 5% probability level. It indicates that one-day increase in training would increase the probability of adoption of CA technologies by 2.1%. That means if we can increase the training on CA practices, the adoption of CA technologies will increase.

Drought events had a negative value of dy/dx which was -0.480 and statistically significant at 5% probability level which means that one-unit increase in drought events would decrease the

probability of adoption of CA technologies by 48.07%. The negative value of dy/dx indicates that the probability of adoption of CA practices is 48.07% lower for drought events for practicing CA technologies.

CHAPTER FIVE
SUMMARY, CONCLUSION AND RECOMMENDATION

5.1 Summary

5.1.1 Age Distribution

The age distribution of the farmers scores ranged from 20 to More than 60 with a mean and standard deviation for CA adaptor is 4.14 and .774, for non-adaptor mean and standard deviation is 4.06 and .984 respectively. For CA adopter farmers 1.6 percent belonged to the age group of 21-30 years, 17.2 percent belonged to the age group of 31-40 years, 48.4 percent fell into the age group of 41-50 years, 31.3 percent fell into the group of 51-60 years, and 1.6 percent above 60 for adaptor of CA practices. And out of total 36 sample farmers 2.8 percentage belonged to the group of 21-30 years, 30.6 percentage belonged to the group of 31-40 years, 30.6 percentage fell into the age group of 41-50, 30.6 percentage fell into the group of 51-60 years and 5.6 percentage above 60 years old. This finding imply that majority of the sample farmers were in the most active age group of 31-50 years indicating that they provided more physical efforts for farming.

5.1.2 Education

The level of educational scores of the CA farmers ranged from 0 to more than 12 with a mean and standard deviation for CA adopter is 1.98 and .454 respectively. Again mean and standard deviation for CA non-adopter is 2.00 and 0.535 respectively. Respondent under secondary education category constitute the highest proportion (84.4 percent) for CA adopter and (80.6 percent) for CA non-adopter followed by primary (9.4 percent) for CA adopter and (11.1 percent) for CA non-adopter.

5.1.3 Farm size

The farm size of the CA farmers ranged from 0.02 ha to 3.00 ha with a mean and standard deviation for CA adaptor is 3.5469 and .64, for non-adaptor mean and standard deviation is 3.22 and .591 respectively. The researcher found that the small farm holder for CA adapter constitutes the highest proportion 53.1 percent followed by medium farm holder 39.1 percent, whereas 7.8 percent was large farm holder. The researcher also found that the small farm holder for CA non-adapter constitutes the highest proportion 77.8 percent followed by medium farm holder 13.9 percent, whereas 5.6 percent was large farm holder. The findings of the study reveal that majority of the CA adopter and non-adopter farmers were small to medium sized farm holder.

5.1.4 Farmers experience in Agriculture

The total experience in agriculture distribution of the farmers scores ranged from less than 20 to More than 40 with a mean and standard deviation for CA adaptor is 2.09 and 0.771, for non-adaptor mean and standard deviation is 2.17 and 0.971 respectively. For CA adopter farmers 21.9 percent belonged to the group of lower experienced, 50.0 percent belonged to the group of Medium experienced and 25.0 percent fell into the group of high experienced group for adaptor of CA practices. For CA non-adopter farmers 27.8 percentage belonged to the group of lower experienced, 38.9 percentage belonged to the group of Medium experienced and 22.2 percentage fell into the age group of high experienced group. This finding imply that majority of the sample farmers were Medium experienced.

5.1.5 Annual income

For CA adaptor 17.2% farmers are belonged to the group of middle income group, which indicates that their yearly income lies between Tk. 56000 to Tk. 250000. Most of the farmer's yearly income belonged to the category of Tk. 57000-250,000 and it is 77.6%. It refers that most of the farmers were well sufficient by following conservation agriculture practices. On the other hand, for CA non-adaptor 33.3% farmers were in the middle income category which means that their income lies between Tk. 50000 to Tk. 250000. Again remaining only 22.3% were above Tk. 250000. So from this we can conclude that the farmers who practicing conservation agriculture are more advanced and sufficient than farmers who weren't practicing climate smart agriculture.

5.1.6 Knowledge on CA Practice

The score of the knowledge on conservation agriculture ranged from 0 to more than 1.5 with a mean and standard deviation of 3.609 and 0.49 for CA adaptor where for CA non-adaptor the mean and standard deviation for 3.36 and 0.54 respectively. On the basis of knowledge on conservation agriculture farmers were classified into four categories such as, poor knowledge, medium knowledge, high knowledge and very high knowledge on conservation agriculture. The distribution of the farmers according to their knowledge on conservation agriculture scores is shown in the table 5. Findings shown that for CA adaptor has maximum very high knowledge 60.9% where for CA non-adaptor has high knowledge 58.3 percent.

5.1.7 Farmers perception on CA practices

The observed perception scores of the respondents ranged from 1 to 5. Based on their perception, the respondents were classified into five categories namely strongly agree, agree, no opinion, disagree, strongly disagree. The distribution of the farmers according to their perception shows that 82% of farmers strongly agree that CA practices improve productivity, 22% of farmers strongly agree that CA practices reduce pesticide application cost, 52% agree that CA practices reduce pesticide application cost, 24% has no opinion and only 2% disagree with that perception, 84% of farmers disagree that CA technologies are labor intensive, 52% of farmers strongly disagree that CA technologies required special skills, 47% stated that they are disagree with this perception, 62% of farmers strongly agree that CA technologies improve soil structure, protects the soil from nutrients losses., 36% agree with this perception and 2% have no opinion, 64% of farmers strongly agree that CA technologies protects soil surface from erosion, 35% agree with this perception and 1% have no opinion, 80% of farmers strongly agree that CA technologies protects soil from moisture and limited weed growth, 19% agree with this perception and 1% have no opinion.

5.1.8 Contribution of selected characteristics to the adoption of CA practices

Three out of six explanatory variables included in the model were found significant in explaining the variation in adoption probability. These variables were farm size, training on Ca and drought events. the P value for the variables farm size, training on CA and drought events are 0.019, 0.003 and 0.001 respectively which is less than 0.05. That means farm size, training on CA and drought events are statistically significant at 5% level of significance. That means we will reject the null hypothesis for farm size, training on CA and drought events. This interpretation indicates that farm size, training on CA and drought events has a contribution for adoption of CA technologies. Marginal effect was computed differently for discrete (i.e., categorical) and continuous variables. Marginal effect measured discrete change i.e., how predicted probabilities were changed due to change in binary independent variable from 0 to

1. Marginal effects for continuous variables measured the instantaneous rate of change. The age has a negative relation to the adoption of CA practices. That means as a new farming technique conservation agriculture is more popular in young generation than older people. The education also has a negative relation to the adoption of conservation agriculture that means the educated persons are less fond of practicing CA practices than uneducated people. Farm size has a positive relation to the adoption of conservation agriculture and the value of the marginal change is 0.023, it means that for bigger farm size, the probability of adoption of CA technologies is 0.023 times higher than the small farm size compared to not practicing it. This reason was that the small farmers are relatively laggards for new farming practice. Training on CA had a positive value of dy/dx and it was 0.021 and statistically significant at 5% probability level. It meant that more training on CA increases the probability of adoption of CA practices by 0.021 times. That means if we can increase the training on CA practices, the adoption of CA technologies will increase. Drought events had a negative value of dy/dx which was -0.4807 and statistically significant at 5% probability level which means that the drought event has a contribution for adoption of CA technologies. The negative value of dy/dx indicates that the probability of adoption of CA practices is 0.48 times lower for drought events for practicing CA technologies.

5.2 Conclusion

The present high input based agricultural intensification is neither productive nor environmentally sustainable. We need a system resilient to both biotic and abiotic stresses with minimal impact on the environment to produce more per unit area through judicious use of inputs and efficient use of natural resources. Conservation agriculture has several benefits in terms of minimization of cost of production (through savings on fuel, labor, fertilizers, pesticides and water), enhancement of input use efficiency, improvement of soil health with greater biological activities, higher soil Carbon sequestration, reduction of land degradation, minimization of GHGs emissions, facilitation of ecosystem services besides extending sustainability to agricultural intensification and environment. Sustainable intensification of agriculture in South Asia through CA depends largely on farmer-friendly machinery to generate interest among the private manufacturers to invest. Moreover, CA requires a change in mind set, dedication, commitment, attitude, and behaviour of all concerned stakeholders viz. scientists, policy makers, extension workers, NGOs and farmers for its promotion. We must realize that C’ in Conservation Agriculture stands for Carbon. Basically, CA is low carbon agriculture. Goal is to attain carbon neutral agriculture with ultimate goal of attaining carbon negative agriculture.

The study concludes that conservation agriculture, as a new resource saving farming practice was appreciated and successfully adopted by the farmers. It is also revealed that farmers' income was increased through adopting conservation agriculture. Farmers got higher price for their product free from fatal medicine and synthetic fertilizers. This practice helped the farmers to minimize their labor and other input cost. The study also indicates that poverty in terms of deprivation of health, education and living standards was decreased; and overall socioeconomic condition was improved after adopting conservation agriculture practice. Majority of CA adopter farmers avowed about enhanced soil environmental circumstances after adopting conservation agriculture than before, while majority of non-adopter farmers stated about constant soil environmental condition. A number of factors had significant influence on CA adoption probability. Government input support and agricultural extension services should be properly executed and monitored to promote the practice of conservation agriculture. Also, programs for motivating and training the farmers should be arranged by different government and non-government organizations to enhance farmers' knowledge on conservation agriculture practice.

5.3 Recommendations for policy implications

On the basis of observation and conclusions drawn from the findings of the study following recommendations are made to the planners and policy makers in contriving micro or macro level policy for increasing of crop production:

- Education of the farmers had the highest contribution to adoption of CA farmers in Rajshahi and Natore district. It is therefore, recommended that attempt should be taken by the concerned authorities to increase the education of the farmers by regular contact with them.
- Annual income of the farmers also had the highest contribution to adoption of CA farmers in Rajshshi and Natore district. It is therefore, recommended that attempt should be taken by the concerned authorities to increase their annual income of the farmers' by regular contact with them.
- Training received is the next important contributor to the farmers' adoption of conservation agriculture. It is therefore, recommended that necessary step should be taken by the concerned authorities to increase the training received facility of the farmers by regular contact with them.
- Drought event is the next contributor that has impact on the farmers' adoption of conservation agriculture. It is therefore, recommended that attempt should be taken by the concerned authorities in the drought prone areas.

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Appendix - A

An English Version of
Interview Schedule Dept. of
Management and Finance

Sher-e-Bangla Agricultural
University Interview Schedule

A Study on factors affecting the adoption of Climate Smart Agriculture (CSA) / Conservation Agricultural (CA) practices in northern part of Bangladesh

Sample no.: --------------

1. **General information:**

Name: ………………………………………… **Upazila:** …………………

District: ………………….   **Contact No:** …………………………..

2. **Respondents profile:**

Sl#	Relationship	Age (yrs)	Education (yrs)	Main occupation*	Family size	Working people
1	**Self**					
2						

*Occupation code: 1 =Agriculture, 2= service, 3=business, 4= unemployed, 5=others

3. **Farm Size:**

Land type	Area (ha.)
Own cultivated land	
Sharecrop out	
Sharecrop in	
Lease out	
Lease in	

Homestead	
Pond	

Explain clearly about climate smart / conservation agricultural practices. After explanation start the following section.

4. Do you ever heard (aware) about CSA/CA practices? Yes (1) / No (0)

If yes, from where: ……………………………………

5. Knowledge on CSA/CA practices: Please answer the following question

SL. NO	Questions	Full Marks	Marks Obtained
1	What do you mean by CSA/CA?	(2)	
2	Mention two examples of CSA/CA practices.	(2)	
3	**What is zero tillage?**	(2)	
4	**What is cover crop?**	(2)	
5	**What is zero/minimum tillage**	(2)	
6	What is green manure?	(2)	
7	How to use crop residue in crop field?	(2)	
10	What are the benefits of guti Urea?	(2)	
11	What are the advantages of AWD (Alternative Wetting and Drying)?	(2)	
12	What is the benefit of Agro-forestry?	(2)	
13	What are the advantages of IPM?	(2)	
14	What do you mean by drought resistant variety?	(2)	

6. **Do you adopted the following practices in your crop field?**

Sl#	Practices	Yes (1)	If yes, land area (ha.)	No (0)
1	**Zero tillage**			
2	**Minimum tillage**			
3	**Crop rotation**			
4	**Cover crop**			
5	**Crop residue**			
6	Construction of mini-pond in crop field			
7	Drought resistant rice variety			
8	Green manuring			
9	Agro-forestry			
10	Use of IPM			
11	Use AWD			
12	Unpuddled rice transplanting system by strip and raised bed method			
13	Rain water harvesting			

7. Farmers' perception on CSA/CA (IF #6 is 'NO' then ignore this question):

Sl#	Farmers perception	Extent of farmer's perception				
		Strongly agree (5)	Agree (4)	No Opinion (3)	Disagree (2)	Strongly Disagree (1)
1	Improve productivity					
2	Reduces pesticide application cost					
3	Good for environment					
4	Labour intensive					
5	Required special skill					
6	Increase income					
7	Require high investment cost					
8	CA/CSA improves soil structure, protects the soil from erosion and nutrients losses					
9	Crop residues on the soil surface enhance water holding capacity					
10	Conservation tillage/reduced tillage protects soil surface					
11	Cover crops protects soil from moisture and limited weed growth					

8. Other information about respondent's (last one-year information):

Questions	**YES**	**NO**	**If yes**	
			times	**days**
a. Have you received any agriculture related training?				
b. Did you visited extension office/SAAO for advice?				
c. Have you received any training on CSA/CA?				
d. Did you visit extension office/SAAO for CSA/CA advice?				
e. Are you confident about SAAO advice?				
f. Do you think **CSA** practices are available in your area?				
g. Do you have any bank account?				
h. Did you receive any agriculture related credit?				
i. Are you a member in any societal organization?				

j. Did you experience any health-related issues which hamper your activity?				
k. Did you experience any labour crisis to work in your field?				
l. Is there any IPM club in your village?				
m. Is there any climate field school in your village/upazila?				
n. 1. Are you a member of IPM club?				
n.2. Are you a member of climate field school?				
o. Do you have electricity in your house?				
p. Do you have pacca road in your village?				
q. Do you have any service provider in your village/upazila?				
r. Availability of climate related information in your area.				
s. How many months in a year you can consume from your own production? (months)				
t. Distance of your home to local market (km).				
u. Distance to upazila agriculture office from home (km).				
v. Distance of your home to highway (km).				
w. Your total experience in agriculture (years).				
x. How long you are practicing CSA/CA? (years)				
y. How do you get information related to CSA/CA? *				
z. Housing condition of the respondent.**				
aa. Severity of extreme events like drought in your upazila.***				
bb. Soil type where you adopted CSA/ CA.****				

Code: ***Information**: 1 Radio, 2 TV, 3 NGO Workers, 4 Extension Workers, 5 Neighbor, 6 newspaper, 7 service provider, 8 others; ****House condition:** 1 building, 2 tin shed, 3 others; *****Events**: 3 extreme severe, 2 moderate, 1 low, 0 none; ****Soil: 1 clay, 2 sandy, 3 loam, 4 sandy loam, 5 others

9. Annual Income

	Source of income	Income (Tk.)		Source of income	Income (Tk.)
Agricultural	Rice		Occupational	Service	
	Wheat			Business	
	Fruits and vegetables			Remittance	
	Livestock and poultry			Others (if any)	
	Fisheries				
	Others				

10. Annual expenditure:

Consumption expenditure ....Tk/yr

Non consumption expenditure ....Tk/yr

11. Problems and suggestion regarding CSA/CA

a. Are there any problems of using CSA/CA practices? Mention them

i ……………………………………………………………………

ii……………………………………………………………………….

iii……………………………………………………………………....

b. Suggestions for future development/adoption of CSA/CA.

i………………………………….………………………

ii…………………………………………………………………………

iii…………………………………….……………………………….

Thanks for your kind co-operation