SUSTAINABILITY OF COASTAL AGRICULTURE IN BANGLADESH

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CERTIFICATE

This is to certify that the thesis entitled **"SUSTAINABILITY OF COASTAL AGRICULTURE IN BANGLADESH"** submitted to the Faculty of Agriculture, Sher-e Bangla Agricultural University, Dhaka, in partial fulfilment of the requirements for the degree of **Master of Science** in **Agricultural Extension**, embodies the result of a piece of bona fide research work carried out by **Md. Mawdud Ahmed**, Registration No. 15-06987 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, received during the course of this investigation has been duly acknowledged.

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DEDICATED

TO

MY BELOVED BROTHER

H M WADUD HOSSAIN

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SUSTAINABILITY OF COASTAL AGRICULTURE IN BANGLADESH[1]

MD. MAWDUD AHMED[2]

ABSTRACT

Coastal agriculture in Bangladesh has facing a multitude of climate and non-climate related challenges. The government has been taking numerous initiatives for improving coastal agriculture. The objectives of the study were to select and describe a set of indicators of sustainable coastal agriculture, to assess the sustainability of coastal agriculture in Bangladesh and to formulate relevant policy information. The sustainability of coastal agriculture was assessed by developing a composite sustainability index (CSI) consisting three dimensions: economic, social and environmental. An essential set of indicators were developed by reviewing literature and appraising experts' opinions. Data were collected from 120 coastal farmers of six villages of three coastal upazilas, namely Gournadi (Barisal), Dumki (Patuakhali) and Nesarabad (Pirojpur). The results revealed that: i) about 60% coastal farmers had reasonably to highly sustainable agriculture in terms of aforementioned three dimensions and ii) using multiple regression analysis (standardized beta), the most contributing factors were land productivity, adequacy of extension services and access to information on climate and cropping practices. Research findings indicate that these three factors played a vital role in achieving sustainable coastal agriculture. The study concluded that information, technologies and productivity are key factors for fostering sustainable coastal agriculture. A number of policy recommendations (e.g., effective initiatives were needed to increase productivity, such as increasing irrigation coverage and providing high quality hybrid seeds) were made based on the findings of the study to achieve sustainable coastal agriculture in Bangladesh.

Key words: Sustainability, coastal agriculture, composite sustainability index, climate smart agriculture.

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CHAPTER 1

Introduction

1.1 Background of the study

Bangladesh is an agriculture dependent country. Agriculture plays a vital role in Bangladesh economy. More than 70% people in the rural areas directly or indirectly are involved with agriculture (BBS, 2011 and MoEF, 2012). It employs nearly 47.5% of labour force and contributes one sixth of gross national product of the country (GoB, 2013). Agriculture in the coastal area of Bangladesh experiences significant hazards and is highly vulnerable to climate and environmental change over the coming decades. Agriculture is the most important livelihood option for the coastal people of Bangladesh (GoB and UNDP, 2009). About 40 million people of the coastal areas of Bangladesh depend on agriculture (BBS, 2011). Agriculture is the most important user of natural resources like soil, water, air and energy, and its sustainability depends upon their proper use and protection of these resources (DFID, 2002). In Bangladesh, where agriculture is the main source of livelihood of two-thirds of the rural population, a serious concern has arisen about the sustainability of agriculture in the face of deterioration of land quality, declining yield, and increased population. Being a land-scarce country, emphasis has been given to increasing food production by intensifying the use of land, inorganic fertilizers, pesticides and water. Subsidies are provided on inorganic fertilizers, pesticides and irrigation equipment to enable farmers to adopt these technologies for in-creasing crop yields (Hossain, 1988). Farmers cultivate both local and HYV aman rice in kharif-II season and in kharif-I and rabi seasons, the salinity intensity becomes higher and most of the farmers grow vegetables in their homestead for their own consumption. A total of 48 upazillas of 12 districts meet the sea directly and a vast amount of people of coastal zone are dependent on agriculture for their living. Different types of natural hazards including flood, cyclone and storm surges, tidal surges/intrusion of saline water, salinity, water-logging/submergence, drought, river bank erosion, tornadoes etc. affect the country almost every year. These catastrophic events significantly hinder the agriculture production, economic and social development of the country through two processes: first, damaging the crops, livestock, fisheries and agro-forestry, natural resources, establishments and infrastructures and secondly, pulling back the on-going developments, business and trade at local, regional and even global levels. Specially, coastal agriculture is facing a number of challenges from natural and manmade hazards like salinity, seasonal flood, river erosion etc. Moreover, living standards of coastal farmers are getting deteriorated day by day due to poor communication system, limited health facilities, poor marketing system etc. Therefore, sustainable agricultural production is the crying need for the coastal people. Agricultural sustainability refers to the maintenance of quantity as well as quality of agricultural products over a long period of time with considering wider economic, environmental and social outcomes. Sustainability is a multi-scalar concept that has both temporal and spatial dimensions (Go ´mez-Limo ´n and Sanchez-Fernandez 2010; Bell and Morse 2008). People have a lack of better understanding on the matter. Concerns about sustainability centre on the need to develop agricultural technologies and practices that: i) do not have adverse effects on the environment (partly because environment is an important asset for farming), ii) are accessible to and effective for farmers, and iii) lead to both improvements in productivity and have positive side effects on environmental goods and services (Jules Pretty 2003). Proper policy may play a vital role for achieving the target of achieving sustainable coastal agriculture. For example, resource management, minimizing adverse effects of natural hazards, efficient agricultural production etc. can be the key factors to have a sustainable agriculture for the coastal zone of Bangladesh.

1.2 Coastal Zone of Bangladesh

The coastal area of Bangladesh borders the Bay of Bengal and has three distinct geographic sections, the Sundarban mangrove forest in the southwest, the very active delta in the central south, and the narrow coastal strip along the Chittagong and Chittagong Hill Tracts area on the east. (Soussan et al., 2003). The country has 716 km long coastline. The landward distance of the delineated coastal zone from the shore is between 30 and 195 km whereas the exposed coast is between 37 and 57 km (A. Nishat and N. Mukherjee, 2013). The Coastal Zone Policy considers three indicators for determining the landward boundaries of the coastal zone of Bangladesh, which are: influence of tidal waters, salinity intrusion and cyclones/storm surges (Ministry of Water Resources, 2005). The coastal areas of Bangladesh is different from rest of the country not only because of its unique geo-physical characteristics but also for different socio-political consequences that often limits people’s access to endowed resources and perpetuate risk and vulnerabilities. Coastal areas include coastal plain islands, tidal flats, estuaries, neritic and offshore waters. The Bay of Bengal occupies an area of about 2.2 million sq. kilometres, and the average depth is 2,600m with a maximum depth of 5,258m; Bangladesh is at the top of it (DoE, 2010). The coastline is 716 km long and the coastal area of the country is virtually a conglomerate of rivers and islands and hosts a unique diversity of ecosystems (DoE, 2006). People living in different coastal areas of Bangladesh have been suffering from lack of food security with lower crop productivity, less cropping intensity, unemployment, large fallow lands/water bodies and land degradation due to various soil-related constraints, climate risks and socio-economic problems. Since people do not have ample employment opportunities round the year, their food security situation is vulnerable and is a matter of great concern for the policy makers. Majority of the people in coastal areas are involved in crop cultivation and fishing and they remain frequently unemployed due to tidal flooding and other natural disasters resulting food insecurity in the areas. It extends to the edge of a wide (about 20 km) continental. Among the 25 bio-ecological zones of the country, 11 are wholly situated in the coastal zone, 4 others have parts of them in the coast. The countries coastal ecosystems include mangroves, coral reefs, sea grass beds, sandy beaches, sand dunes, Inter-tidal and subtidal wetlands and mudflats, flood plain, salt Marshes, estuaries, lagoons, peninsula, offshore islands, tropical hill forest etc. Major part of the world's largest mangrove "Sundarbans" is one of its key ecosystems. But these ecosystems are degrading alarmingly due to various external pressures especially due to pollution and exploitation. From a coastal zone management point of view, the delineation of the coastal zone was done by the Ministry of Water Resources, and the 6th meeting of the Inter-ministerial Technical Committee for the Integrated Coastal Zone Management Plan defined the coastal zone of the country as the total area of 19 coastal districts that are again subdivided into 147 upazillas, including the Exclusive Economic Zone (MoWR, 2003). A total of 48 out of 147 upazillas of 12 districts meet the sea directly and defined as 'exposed coast', and rest of the upazillas are defined as 'interior coast'. The coastal area of Bangladesh can be divided into three distinct zones; the southwest, south central and southeast zone. The southwest and south-central zones are low in elevation height and flat in nature.

1.3 Statement of the Problems:

The coast of Bangladesh is known as a zone of vulnerabilities as well as opportunities (Subramanian, 2012). Coastal zones are particularly vulnerable because of its dynamic environmental settings. Coastal regions of Bangladesh is at great risk from projected sea-level rising. Coastal zone resources are especially endangered by the projected climate change and consequent sea-level rising (Table 1.1). Potential impacts (Agarwala et al., 2003) would include: (i) changes in water levels and induced inundations and water logging, (ii) increased salinity in ground and surface water, and corresponding impacts on soil salinity, (iii) increased coastal morphological dynamics (erosion and accretion), and (iv) increased incidence of natural hazards. These impacts will lead to the reduction of the economic and employment opportunities in the coastal areas, already under stress by occurrence of cyclones and storm surges. The combination of natural and man-made hazards (table 1.1), such as erosion, high arsenic content in ground water, water logging, water and soil salinity, various forms of pollution, risks from climate change, etc. have adversely affected lives and livelihoods in the coastal zone and slowed down the pace of social and economic developments in this region.

Table 1.1: Major problems of coastal agriculture in Bangladesh	
Major Problems	**Definition of the Problems**
Salinity Intrusion	Coastal land of Bangladesh is highly affected by salinity intrusion because of its low elevation. Soil salinity of the coastal zone is increasing year after year and its expansion is varied depending on the condition of coastal area. It may exist in coastal soil of a few kilometres from the coastline that could widen up, as further as 180 km landward. Besides, the salinity level of coastal soil varies from region to region. Areas closer to the shoreline are more saline-prone than those further inland.
Sea-Level Rise (SLR)	Sea level rise due to global warming has become a great concern in present time. Especially coastal area of Bangladesh is going to be a major victim to this problem. Based on global trend (Choudhury et al. 1997) postulated a sea-level rise of 10–15 mm/year along the Bangladesh coast that seems to be an underestimation compare to 4–7.8 mm/year assessment of Singh (2002). Things responsible for the hazard should be controlled immediately to reduce the rising of the sea level.
Coastal Flooding	Having low-lying elevation, the coastal zone of the country is subject to different type of floods. Fifty percent of coastal lands are featured with permanent or temporary inundation that reduces the effectiveness of coastal land (Islam 2006). Coastal flooding, including flush flood needs due attention to protect coastal land from water stagnation and water logging.
Cyclone	Cyclone is the most known name to the coastal people. Because, they face 8-10 cyclones per year. Cyclone has two types of effects on coastal land. First, it wipes-out all standing crops in the field converting productive land to a barren field all at a sudden. Second, the long-term impact of cyclone is the storm surges that could go as high as 9.1 m of wave height with an outcome of the transportation of saline water into the coastal land resulting in salinization of coastal soil (Khalil 1993).
Poor communication system and infrastructure	Communication system of the coastal region is very poor. Coastal farmers also have a little storage and marketing facilities. For these reasons, they have to sell their products in the local market. As a result they don’t get proper price of their produces. Besides poor marketing system deprives them from getting original price of the produces.

1.4 Objectives of the Study:

1. To select and describe a set of indicators of sustainable coastal agriculture
2. To assess the sustainability of coastal agriculture in Bangladesh
3. To formulate policy implication to overcome the challenges of coastal agriculture and to foster sustainable coastal agriculture

1.5 Justification of the Research

Agriculture is the dominant sector for the economic growth of Bangladesh. The agricultural system especially the coastal agriculture is heavily dependent on climatic factors such as the timing, intensity and distribution of the monsoon, natural hazards, soil salinity, the availability of freshwater for irrigation and so on. Sustainable agriculture emphasises on better use of on-farm resources and the reduction of external inputs. Sustainable agriculture has some special properties that differs it from conventional agriculture. Those properties are productivity, environmental stability, economical profitability, and social and economic equity. Sustainability of coastal agriculture can be achieved by better addressing of some issues such as climate change risk, adaptation measures, capacity building measures, crop diversification, soil fertility management, pests and diseases management, use of agrochemicals and environmental issues. A study was conducted by Rasul and Thapa (2004) on sustainability of ecological and conventional agricultural systems in Bangladesh. It shows that there is no gold standard for designing indicator systems development process; however, there are some best practices and principles like using the 'pedigree' and highlighting to measurements of quality of life and ecological integrity those can be taken into account. Some studies have emphasized biophysical and socio-economic conditions of the study area as major criteria for selecting indicators in Bangladesh (Rasul and Thapa, 2004). Roy and Chan (2011) carried out a study on assessment of agricultural sustainability indicators in Bangladesh and proposed a complete set of indicators for agricultural sustainability assessment at the farm level in Bangladesh conceptualizing the effects of intensification of agriculture and climate change. Agricultural sustainability assessment for sustainable agricultural development needs a consolidated approach of modern science blended with expert knowledge and active participation of stakeholders. Therefore, this paper suggests the integration of approaches as well as participatory process in sustainability assessment, which ultimately helps to formulate a comprehensive policy strategy for sustainable agricultural systems, as sustainable agricultural development is for ‘our common future’(Roy and Chan, 2011). There have been some other work on sustainability of coastal agriculture of Bangladesh but the previous studies have not adequately explained the phenomenon. Therefore, further work should be done on sustainability of coastal agriculture of Bangladesh to satisfy the above things.

1.6 Scope of the Study:

The basic concern of the study is to assess the sustainability of coastal agriculture in Bangladesh. Sustainability is very important phenomenon for coastal people especially coastal farmers and it can be achieved by adopting some strategic and novel ways. This researcher has tried to design a model for assessing sustainability that will help in policy making and enabling coastal farmers as their own support.

Agriculture is the main livelihood option for coastal people. But coastal farmers face a lot of problems in their daily life particularly in the hazard prone exposed zone farmers. They need safe and better living condition as well as stable agricultural production. In this study, livelihood conditions and the issues of poverty and vulnerability are implicitly addressed so that proper authority easily can go for a solution to these problems. Here, issues of social protection and safety nets get exclusive and concerted attention also. This study gives attention in coordination and communication among the respective governmental agencies those need to be improved. The findings of the study were expected to be helpful to the researchers and research organizations. These might be supplementing other empirical evidences to different aspects of sustainable agriculture in order to build up enough idea on coastal agricultural sustainability. While many aspects of the present agricultural systems appear to be attractive, there is no conclusive evidence about the long term benefits to individuals and the wider community. In this situation, it is expected that the study will assist farm families and policy makers in understanding the features of coastal agricultural sustainability.

1.7 Assumptions of the Study:

The researcher had the following assumptions in mind while undertaking this study.

1. The respondents selected for the study were competent for providing appropriate answer to the queries made by the researcher.
2. Questions and scales used for measuring the variables were enough to get the real views and opinions from the respondents.
3. Views and opinions provided by the respondents were representative of the whole population of the study area.
4. Study area or conditions were more or less similar.
5. Data for the study were bias free, valid and reliable.
6. Findings of the study are expected to be useful for formulating policy information to overcome the challenges of coastal agriculture.

1.8 Limitations of the Study:

Considering the time, money and other necessary resources available to make the study manageable and meaningful, it was necessary to consider the following limitations:

1. The study was confined mainly to 9 selected indicators of sustainability of coastal agriculture.
2. The study was conducted only in 6 villages under 3 upazillas of Barisal, Patuakhali and Pirojpur district not the whole coastal zone.
3. Characteristics of the farmers are many and varied but only some were selected for this study.
4. Facts and figures were collected by the investigator applied to the present situation in the selected area.
5. Many of the factors of farmers and situations were excluded from the investigation due to the limitations of time, money and other resources.
6. Findings of the study will help to achieve agricultural cropping sustainability of the coastal area but not equally applicable for the whole agricultural conditions.

1.9 Definitions of the Terms and Concepts

Access to financial institution: It is the ability of individuals or enterprises to obtain financial services, including credit, deposit, payment, insurance, and other risk management services. Those who involuntarily have no or only limited access to financial services are referred to as the unbanked or under banked, respectively.

Climate change: Climate change refers to a change in the state of the climate that can be identified (e.g. by using statistical tests) by changes in the mean and/or the variability of its properties, and that persists for an extended period, typically decades or longer. Reduces /removes greenhouse gases (mitigation), and enhances the achievement of national food security and development goals.

Climate Information: Information related to different climate related factors such as storm, cyclone, Flood, rain etc. when, where and in what extent will occur are called climate information.

Climate-smart agriculture (CSA): Agriculture that sustainably increases productivity, resilience (adaptation), reduces/removes greenhouse gases (mitigation), and enhances the achievement of national food security and development goals.

Coastal Zone: Coastal zone is most frequently defined as "land affected by its proximity to the sea and that part of the sea affected by its proximity to the land" or, in other words, the area where the processes which depend on the sea-land interaction are the most intensive. In brief, coastal zone refers to areas where land and sea meet (Islam, 2004).

Crop diversification: Crop diversification refers to the addition of new crops or cropping systems to agricultural production on a particular farm taking into account the different returns from value-added crops with complementary marketing opportunities.

Extension Services: Agricultural extension department of Bangladesh provides various services to the farmers. These services are called extension services.

Human Capital: Human capital is a collection of resources—all the knowledge, talents, skills, abilities, experience, intelligence, training, judgment, and wisdom possessed individually and collectively by individuals in a population.

Integrated Pest Management: Integrated Pest Management (IPM) is a process consisting of the balanced use of cultural, biological, and chemical procedures that are environmentally compatible, economically feasible, and socially acceptable to reduce pest populations to tolerable levels.

Land Ownership: Possession of land by the farmers for their living and agricultural use is called land ownership.

Land Productivity: Land productivity is measured as the ratio of agricultural outputs to agricultural inputs where individual products are usually measured by weight, their varying densities etc. It is the amount that a unit of land yields per year.

Natural Resources: Natural resources are useful raw materials that we get from the Earth. They occur naturally, which means that humans cannot make natural resources. Instead, we use and modify natural resources in ways that are beneficial to us. The materials used in human-made objects are natural resources.

Resource Conserving Technology: It is the strategy or mechanism by which we conserve our resources (natural resources).

Sustainability: Meeting the needs of the present without compromising the ability of future generations to meet their needs. Sustainability is a concept describing mankind's ability to create a world for human and non-humans that environmentally, socially and economically provides for a current population's need without damaging the ability of future generations to take care of themselves (Blackburn, 2007).

Vulnerability: Vulnerability can be defined as the propensity or predisposition to be adversely affected (IPCC, 2012). It is a complex concept (Fellmann, 2012) that needs to be considered across scales and across various dimensions (Gitz and Meybeck, 2012).

Yield Stability: Yield stability refers to how stable the yield of an agricultural system is over time from one year to another. An agricultural system with high yield stability will output about the same amount of food each year. Moreover, yield stability of an agricultural system has important human consequences.

CHAPTER II

Review of Literature

2.1 Introduction

This chapter is a review of past studies having relevance to this research and for this reason, the researcher made an elaborate search for available literatures on different sources. Available literature was extensively reviewed to find out work in Bangladesh as well as abroad. Moreover, the investigator extensively went through the available literatures from various sources, which enriched his knowledge and gave a clear understanding on the topic. The purpose of this chapter is to review the extant literature and identify pertinent gaps with a view to fulfil the objectives of the study. The literatures collected for the study have been presented in different sections.

2.2 Literature Review of Important Terms

2.2.1 Sustainability

Many researchers and scholars have given different definition of sustainability. Various opinions and views have made the term much ambiguous. In this research, sustainability has been discussed in the light of agricultural aspects. Despite the diversity in conceptualizing sustainable agriculture, there is a consensus on three basic dimensions of the concept (Cai and Smith, 1994; Hansen, 1996). These are: (i) 'ecological sound-ness', which refers to the preservation and improvement of the natural environment; (ii) 'economic viability' which refers to maintenance of yields and productivity of crops and livestock; and (iii) 'social acceptability' which refers to self-reliance, equality and improved quality of life.

Rasul and Thapa (2004) also shared such a view. In their study, sustainable agriculture is conceptualised based on three dimensions of the concept, as follows:

- Environmental soundness: reasonable use of external inputs to prevent land and water resources degradation and reduce the risks of human health hazards.
- Economic viability: ensure stable and profitable production activities.
- Socio-institutional acceptance: ensure food self-sufficiency and a greater adoption of resource conservation technologies and practices to control or prevent resource degradation through effective institutional services.

According to Crews et al. (1991) in the agricultural sector, the normative focus of sustainability perception is predominantly based on ecological and/or economic aspects.

According to Holling et al. (1998) sustainability has some features those cover a basic standard. For the sustainability of a system, it has to possess those features. For sustainability, biological diversity needs to be increased to recreate natural control and regulation functions and to manage pests and diseases rather than seeking to eliminate them. Mature ecosystems are now known to be not stable and unchanging, but in a state of dynamic equilibrium that buffers against large shocks and stresses. Modern agro-ecosystems have weak resilience, and for transitions towards sustainability need to focus on structures and functions that improve resilience.

Simon (1989) summarized the variables proposed for use as performance indicators of agro-ecological systems. He considered sustainability as the central focus, linking the physical environment to local human activity and the wider political economy.
Pretty et al. (1995) studied on "Regenerating Agriculture: policies and practice for sustainability and self-reliance" and found that different expressions have come to be used to imply greater sustainability in some agricultural systems over prevailing ones (both pre-industrial and industrialized). These include bio-dynamic, community based, eco-agriculture, ecological, environmentally sensitive, extensive, farm fresh, free range, low input, organic, permaculture, sustainable and wise use.

Some researchers emphasized on some approaches those are needed to attain a sustainable agro-ecosystem. According to Kloppenburg et al. (1996), converting an agro-ecosystem to a more sustainable design is complex, and generally requires a landscape or bioregional approach to restoration or management.

Dobbs and Pretty (2004) in their study "Agri-environmental stewardship schemes and multi-functionality" showed the improvement from the adoption of sustainable agricultural practices. It has also been argued that farmers adopting more sustainable agro-ecosystems are internalizing many of the agricultural externalities associated with intensive farming and hence could be compensated for effectively providing environmental goods and services. Providing such compensation or incentives would be likely to increase the adoption of resource conserving technologies.

Altieri (1995) also showed the positive effects of sustainable agriculture. Farmers can improve the biological stability and resilience of the system by choosing more suitable crops, rotating them, growing a mixture of crops and irrigating, mulching and manuring land.

Beus and Dunlop (1994) considered agricultural practices such as the use of pesticides and inorganic fertilizers, and maintenance of diversity as measures of sustainability. For sustainable agriculture, a major requirement is sustainable management of land and water resources.

Islam (2006) revealed in his study that along with disasters, the agricultural practices of coastal areas are always under threat. The coastal agriculture is transforming recently.

2.2.2 Agricultural Sustainability

Department for International Development (DFID, 2002) provided a key sheets for sustainable livelihoods that gave a concept of sustainable agriculture. Agricultural sustainability implies the capacity to adapt and change as external and internal conditions change. The conceptual parameters have broadened from focus on environmental aspects to include first productivity and then wider social and economic dimensions. These four goals of sustainable agricultural are relative dimension depends on time, place, socio-economic and political condition. Key features of agricultural sustainability include an acceptance of the fact that agricultural strategies should be based on more than simple productivity criteria, those externalities in assessing agricultural change.

Other researchers have also defined sustainable agriculture depending on their study. For example, Pretty (2002) defines that sustainable agriculture seeks to make the best use of nature's goods and services, of the knowledge and skills of farmers, and of people's collective capacity to work together to solve common management problems. Such systems are improving soil health, increasing water efficiency and reducing dependency on pesticides. Likewise, ATTRA-National Sustainable Agriculture Information Service defined sustainable agriculture as also the agriculture of social values, one whose success is indistinguishable from vibrant rural communities, rich lives for families on the farm, and wholesome a food for everyone.

Moreover, Norman et al. (1997) have given a definition of sustainable agriculture. According to them, sustainable agriculture is a dynamic rather than static concept. What may contribute towards sustainability today may not work as the system changes, thus requiring a high level of observation and skills that can adapt to change. Consequently, sustainability is a direction/process and does not by itself result in a final fixed product, making it even more difficult to monitor and/or measure.

According to Hansen (1996) despite wide consensus on its relevance, there is some consensus about the dentition of ‘‘sustainable agriculture’’ as an activity that permanently satisfies a given set of conditions for an indefinite period of time.

Allen et al. (1991) emphasized on major three dimensions with their spatial and temporal scales. They said, corresponding to the general multidimensional sustainability paradigm, definitions of sustainable agriculture have to include ecological, economic and social aspects with respect to their diverse spatial and temporal scales.

Dobbs and Pretty, (2004) showed benefits of sustainable agriculture. The idea of agricultural sustainability, though, does not mean ruling out any technologies or practices on ideological grounds. If a technology works to improve productivity for farmers and does not cause undue harm to the environment, then it is likely to have some sustainability benefits. Agricultural systems emphasizing these principles also tend to be multifunctional within landscapes and economies.

Carney (1998) gave some comparison between sustainable and unsustainable agricultural system. According to his study, sustainable agricultural systems tend to have a positive effect on natural, social and human capital, while unsustainable ones feedback to deplete these assets, leaving fewer for future generations. For example, an agricultural system that erodes soil while producing food externalizes costs that others must bear. But one that sequesters carbon in soils through organic matter accumulation helps to mediate climate change. Similarly, a diverse agricultural system that enhances on-farm wildlife for pest control contributes to wider stocks of biodiversity, while simplified modernized systems that eliminate wildlife do not. Agricultural systems that offer labour-absorption opportunities, through resource improvements or value-added activities, can boost local economies and help to reverse rural-to-urban migration patterns.

Agricultural sustainability can be measured by examining the changes in yields and total factor productivity. Beus and Dunlop (1994) considered agricultural practices like the use of pesticides and inorganic fertilizers, and maintenance of diversity as the measures of sustainability. For sustainable agriculture, a major requirement is sustainable management of land and water resources.

According to Ikerd (1993) it is difficult to measure sustainability precisely. He revealed that the precise measurement of sustainability is impossible as it is site-specific and a dynamic concept.

Pretty (1995) added to Ikerd (1993) that although precise measurement of sustainable agriculture is not possible, when specific parameters or criteria are selected, it is possible to say whether certain trends are steady, going up or going down.

2.2.3 Coastal Zone

Islam (2004) defined coastal zones as the area where sea attaches to the land. He said that coastal zones refer to areas where land and sea meet.

Ministry of Water Resources (2005) gave an outline of the coastal zone of Bangladesh. According to their report, Bangladesh is located at the head of the Bay of Bengal, and the country has a coastline of approximately 710 km. The Coastal Zone Policy considers three indicators for determining the landward boundaries of the coastal zone of Bangladesh, which are: influence of tidal waters, salinity intrusion and cyclones/storm.

Coastal zone is different in a number of aspects from rest of the country. A participatory and integrated approach holds the promise of reducing conflicts in the utilization of coastal resources and optimum exploitation of opportunities. The Government, therefore, has formulated this coastal zone policy (CZPo, 2005) that would provide a general guidance to all concerned for the management and development of the coastal zone in a manner so that the coastal people are able to pursue their life and livelihoods within secure and conducive environment.

UNDP report (2000) revealed the scenario of coastal population in the world. In many parts of the world, coastal areas are highly populated and often the most developed stretches of land. It is estimated that 40% of the world population lives within 100 km of a coastline.

Islam and Ahmad (2004) and Islam et al. (2006) discussed the issues of the coastal area. Their study showed that management of coastal zone of Bangladesh is a challenging task since it has to address many issues related to natural system and socio-economic system.

2.2.4 Sustainability Indicators

Braat (1991) defined sustainability indicators as indicators that provide information, directly or indirectly, about the future viability of specified levels of social objectives such as material welfare, environmental quality, and natural amenity.

OECD (2001) has also identified a complete set of environmental indicators for agriculture, which includes the linkages and trade-offs between different management practices and their impact on the environment such as: whole farm management involving the overall farming system; and farm management aimed at specific practices related to nutrients, pests, soils, and irrigation.

Webster (1999) discussed about the applicability of the OECD indicators. He said that most of the indicators mentioned in OECD framework are suitable to evaluate agricultural sustainability at aggregate level. They cannot, however, be used to assess sustainability at the farm level, although individual farmers take the major decision in land-use including mode of use and choice of technology.

According to Dumanski and Pieri (1996) indicators should be location specific, constructed within the context of contemporary socioeconomic situation.

Stockle et al. (1994) proposed a framework for evaluating the relative sustainability of a farming system using nine attributes; productivity, profitability, soil quality, water quality, air quality, energy efficiency, fish and wildlife habitat, quality of life and social acceptance. They recommended scoring based on quantifiable constraints within each attribute. Other evaluation techniques such as expert opinion and computer simulation models were also suggested, if direct measurement is not possible.

Zhen and Routray (2003) also proposed a set of operational indicators for measuring agricultural sustainability in developing countries based on a critical review of relevant literatures over the past 15 years. These indicators include ecological indicators involving soil fertility and irrigation management, economic indicators such as crop productivity and profitability, and social indicators like food self-sufficiency, equality in food and income distribution among farmers, access to resources and support services, and farmers' knowledge and awareness of resource conservation.

According to Senanayake (1991) developing a quantitative measure of sustainability is an important prerequisite to the development of legislative measures for agriculture, such as those being enacted in many countries today. Sustainability indicators are the most prolific and available method for sustainability evaluation within the literature.

Many indicators for assessing agricultural sustainability are found in the development, economics, and environment literatures. Walker and Reuter (1996) saw them falling into two types: condition indicators and trend indicators. Condition indicators are those that define the state of the system relative to a desired state, or those that can be used to assess the condition of the environment. Trend indicators are those that measure how the system has changed, or those that can be used to monitor trends in conditions over time.

Chen (2000) recommended indicators to assess agricultural sustainability in the Chinese context based on population pressure, eco-environmental degradation, insufficient natural resources, and improper management of resources.

Sands and Podmore (2000) applied the environmental sustainability index (ESI) as an indicator to assess sustainability of agricultural systems and applied it to farms in south-eastern Colorado, USA. The most important contribution of this research is that it provided advice as to how individual sustainable indicators can be integrated to provide an overall picture of sustainability.

In "Assessing the Sustainability of Agriculture at the Planning Stage," Smith and McDonald (1998) recently proposed some important indicators to assess the sustainability of farming practices in Australia. From an economic point of view, they argued that profitability indicators such as total production and net farm income are the primary indicators of agricultural sustainability.

Zhen, L. and J. K. Routray (2003) found in their study that an indicator's selection and application must be both space- and time-specific, due to spatial and temporal characteristics of the indicator. Indicators representing the three dimensions of sustainability (economic, social, and ecological) should be prioritized as per the spatial characteristics under concern.

Agricultural sustainability has three main indicators to be evaluated. Different researchers revealed their opinion on those three indicators. They are as follows:

2.2.4.1 Social Indicators: Brklacich et al. (1991) in their study found that, food self-sufficiency is measured to analyse the food security situation of individual farmers. Concerns over food security extend beyond whether supplies will be sufficient to meet dietary and consumption requirements, and self-sufficiency is often included in the assessment of sustainable agriculture. Increasingly, it is recognized that a secure food supply, meaning one accessible to all members of a society, is a vital component of a sustainable food production system.

2.2.4.2 Economic Indicators: According to Rasul (1999) economic indicators are used to measure the productivity, profitability, and stability of farming activities. Productivity is the efficiency of input on output. Productivity is measured from two standpoints: technical efficiency of resources, expressed in terms of physical amounts, and economic efficiency in terms of monetary value.

2.2.4.3 Ecological indicator: Zhen and Routray (2003) showed the importance of ecological indicators to measure agricultural sustainability. Ecological indicators are used to measure soil fertility management and water management. The quality of groundwater for irrigation should also be considered as an indicator for sustainable agricultural practices.

2.3 Variable-wise Literature Review:

2.3.1 Land productivity

Schramski et al. (2013) observed an indicator for sustainable production that will show the level of sustainability of the system. They considered that a one-for-one relationship of energy inputs to outputs, which exists in self-regulating ecosystems, provides a goal for sustainable and organic production and is a holistic, systems-level indicator of the sustainability of agricultural production systems.

Popkin (2003) considered crop yield as the indicator of agricultural performance. He explained it as for decades, crop yield has been treated as a universal indicator of agricultural system performance, while aggregate food output (e.g. the often-cited mandate to increase global output by 70% or more by 2050) is treated as the starting point for most future prescriptions for food and agriculture.

Abedin and Shaw (2013) found that a large area in the coastal districts is virtually unsuitable for a number of crops, while the production of a few other crops is lesser under saline conditions. Since salinity intrusion restricts cultivation of boro and wheat, the potential impact cannot be ascertained.

Golam Sarwar et al. (2013) carried out a research on sustainability of coastal land. In his study he stated a way for increasing productivity performance of the coastal zone. He stated that coastal land use zoning is important to obtain optimum productivity from same area of land. Suitability of coastal land use needs to be identified to avoid land use conflicts. Seasonal sharing of coastal land will also maximize its use potentials and extensive use in cyclone free period will reduce damage from cyclone and flood.

Islam and Sumon (2013) also studied on the effect of stress condition on crop production. They found that the weather-related shocks and stresses impact on agricultural production, affecting both small-scale producers and those working in larger-scale agriculture and non- agricultural enterprises in rural areas.

Consequence of low crop production was studied by Islam et al. (2015) and they found that the loss of agricultural land and crop production due to SLR results in poor socioeconomic condition of the farmers. The present study finds that due to the losses of agricultural land, majority of the farmers (47.9%) of the study area have become poor to poorer. The level of poverty increases and pushes farmers to migrate another place to compensate the losses by alternative sources of income.

2.3.2 Income Generating Activities (IGAs)

According to a research of FAO in Jordan, the main thrust of the women's development activities would be to assist women in the sustainable establishment of income generating activities to be undertaken in or near the home in some pilot villages. This could be also one of the main objectives of the self-help female groups formed with the support of the Project through its reinforcement of group promotion activities. IGAs tend to give women a higher status within the family and studies generally indicate that the greater the amount of income under women's control the greater amount devoted to their children's education, health and nutrition. As previously mentioned generally incomes of women are used for the increase of the well-being of the family. However it is essential to guarantee that women will have the control of the funds (saving funds, loans etc.) and the free disposal of them to implement IGAs. During the feasibility study project staff should be very careful on not raised expectations.

Importance of income generating activities is found by different research done by Davis, 2004; FAO, 1998 and Reardon et al. 2001. While agricultural related activities still constitute the largest share of total income among rural households, a number of empirical studies show the growing importance of RNF activities in developing and transition countries. Surveys of these studies indicate RNF income represents on average 42% of rural income in Africa, 32% in Asia, 40% in Latin America and 44% in Eastern Europe and the CIS.

According to Carletto et al. (2007) the vast majority of rural households in each country of the RIGA dataset participate in on farm activities. The share ranges from 54 to 99 percent by country, with an unweighted average participation rate of 86.2 percent. For non-farm activities, the overall participation rate stands at about 47.7%, while the range of variation across countries is much greater than for agriculture.

2.3.3 Access to Financial Services

Rabbani et al. (2013) stated that the study indicates that more than 70% households take out loans, reduce household expenses and change eating habits to cope with the impact of salinity on rice production.

According to BBS (2007) farmers have very limited access to institutional credit because of collateral requirement. At present, only 27% of farmers receive institutional credit (BBS, 2007). The credit amount again is quite inadequate and not advanced in time. They are also not eligible for microcredit of NGOs that deal mainly with landless farmers.

2.3.4 Human capital

Leeuwis (2004) conducted research on human capacity that contributes in their productivity. They found that human capital is the total capability residing in individuals, based on their stock of knowledge skills, health and nutrition. It is enhanced by access to services such as schools, medical services and adult training. People's productivity is increased by their capacity to interact with productive technologies and other people. Leadership and organizational skills are particularly important in making other resources more valuable.

Olsson and Folke (2001) carried out a research on ecological knowledge and institutional dynamics and found that as a more sustainable agriculture seeks to make the best use of nature's goods and services, technologies and practices must be locally adapted and fitted to place. These are most likely to emerge from new configurations of social capital, comprising relations of trust embodied in new social organizations, new horizontal and vertical partnerships between institutions, and human capital comprising leadership, ingenuity, management skills and capacity to innovate. Agricultural systems with high levels of social and human assets are more able to innovate in the face of uncertainty.

Cramb and Culasero (2003) and Pretty (2003) in their respective study, found that, social capital yields a flow of mutually beneficial collective action, contributing to the cohesiveness of people in their societies. The social assets comprising social capital include norms, values and attitudes that predispose people to cooperate; relations of trust, reciprocity and obligations; and common rules and sanctions mutually agreed or handed down. These are connected and structured in networks and groups.

Pretty et al. (2006) conducted a study on Resource conserving agriculture. In their research they found that sustainable agricultural systems tend to have a positive effect on natural, social and human capital, while unsustainable ones feedback to deplete these assets, leaving fewer for future generations. Agricultural systems that offer labour-absorption opportunities, through resource improvements or value-added activities, can boost local economies and help to reverse rural-to-urban migration patterns.

Pretty (2003) also found that agricultural sustainability does not require that all assets are improved at the same time. One agricultural system that contributes more to these capital assets than the other can be said to be more sustainable, but there may still be trade-offs with one asset increasing as the other falls. In practice, though, there are usually strong links between changes in natural, social and human capital with agricultural systems having many potential effects on all three.

2.3.5 Adequacy of Extension Services

Ommani et al. (2008) Leeuwise and Van den Ben (2004) stated that in order to adapt agricultural extension organizations to sustainability, it has been argued that organizations must become "learning organization".

Senge (1990) conducted a research on The Art and Practice of the Learning Organization. In his study he found that a learning organization expects its members to “act as learning agents for the organization, responding to changes in the internal and external environment of the organization”. Attendance of farmer associations and NGOs are other types of organizational arrangements toward sustainability. Finally, in promoting development of agricultural extension services, the importance of institutional linkage between the rural community and the development agents should be considered.

Allahyari (2009) explained the importance of extension services in attaining sustainability. He stated that extension could play a key role in fostering sustainability through its educational programs but there has been a growing realization that traditional extension models have not been sufficiently effective in promoting adoption of sustainable agricultural practices. Since sustainable agriculture is a knowledge intensive system, it requires a new kind of knowledge, which differs from other forms on the basis of conventional agricultural practices. In fact, conventional extension system cannot accomplish sustainability in agriculture; because today's agricultural extension must consider environmental implications, social issues, and overall economic growth within the agriculture sector. The purpose of this paper is to describe new extension model to achieve sustainable agriculture.

Hersman (2004) conducted a research on knowledge and dissemination of sustainable agriculture practices by county extension agents the extension service can play a crucial role in providing this network of information on sustainable agriculture education.

World Bank (2006) showed the importance of extension agent in a study. They showed, the role of extension is very important to support sustainable agriculture.

According to Rezaei and Karami (2008) the major obstacle to sustainable development of Iran is insufficient knowledge of people with regard to environmental hazards. As a result, the people’s knowledge and environmental awareness to achieve sustainability must be increased. To achieve this objective, extension program could play a key role in helping farmers for the application of sustainable agricultural practices.

Studies done by Van den Ban (1999) and Toness (2001) showed that traditional extension systems have not been sufficiently effective in promoting adoption of sustainable agricultural practices because the traditional roles of transferring and disseminating of agricultural technologies are proving insufficient in today's global context.

Probst and Hagmann (2005) reported while participatory extension approach as a suitable approach for sustainability is emerging, objectives of extension system are shifting toward enhancing adaptive management capacity, emancipation, and social capital at local level, building of stakeholder platforms for negotiations and learning processes.

Cho and Boland (2004) wrote that extension objectives toward sustainability could range from the effective transfer of technology to the building up of strong rural organizations, which can exert influence over future research and policy agendas, and also take and enforce collective decisions over natural resource management. A shift towards the latter will promote more sustainable agricultural development.

Bourdon (2002) have utilized anthropological concepts to define extension toward sustainability. They state that the purpose of extension is to 'help people help themselves.' This idea is still the most appropriate for extension and sustainable development.

According to Allahyari and Chizari (2008) within this new paradigm, sustainable agriculture cannot accomplish by only using conventional extension methods; rather it requires a new kind of learning process-facilitation of learning.

Zhen et al. (2005) found in their study that most of the farmers are dissatisfied (50%) or even strongly dissatisfied (23%) with the present extension services and their agents. The lack of services, limited use of the services by the farmers, no participation of the farmers in general extension activities, an inadequate number of extension workers, the high commercial orientation of the services and the low working efficiency of the AEWs are considered by the farmers as the major reasons for the ineffectiveness of the services.

2.3.6 Access to information on climate and cropping practices

Abramovitz (1997) conducted a research on valuing natures. He found that partly as a result of lack of information, there is little agreement on the economic costs of externalities in agriculture. Some authors suggest that the current system of economic calculations grossly underestimates the current and future value of natural capital.

Three key strategies for knowledge sharing and effective learning will be discussed: the potential of agricultural innovation systems; the use of ICTs and Communication Development approaches for improving access to information; and the role of knowledge networks (FAO, 2013).

2.3.7 Integrated pest and disease management

Khandaker et al. (2011) showed in their study that apart from climate change, proper and timely utilizations of crop protection measures are important, although they are lacking in most places.

Akter (1997) conducted a research on Alternative agriculture in Bangladesh and found that the use of fertilizers, quality seeds, and irrigation together cannot ensure sustainable production unless timely and appropriate measures for the management of pests and diseases are simultaneously pursued. Besides, use of IPM technology is limited to rice and few vegetables.

Akter (1997) also found that a number of nongovernmental organizations (NGOs), namely, UBINIG (Policy Research for Development Alternatives), Proshika, and CARE Bangladesh have launched initiatives in different parts of the country to promote sustainable agriculture. While UBINIG, emphasizes whole farm sustainability, Proshika focuses mainly organic vegetable cultivation and CARE Bangladesh on sustainability of rice production through integrating fish with rice field and adopting integrated pest management (IPM).

Dufour (2001) stated that a premise common to IPM and sustainable agriculture is that a healthy agro-ecosystem depends on healthy soils and managed diversity. One of the reasons modern agriculture has evolved into a system of large monocultures is to decrease the range of variables to be managed. However, a system with few species, much like a table with too few legs, is unstable.

Herren et al. (2005) and Hassanali et al. (2008) conducted several studies and findings of their studies was that IPM which uses ecosystem resilience and diversity for pest, disease and weed control, and seeks only to use pesticides when other options are ineffective.

Herren et al. (2005) and Hassanali et al. (2008) also stated that recent IPM programs, particularly in developing countries, are beginning to show how pesticide use can be reduced and pest management practices can be modified without yield penalties.

2.3.8 Crop Diversification

Stinner & Blair (1990) conducted a research which revealed the importance of crop diversification. They stated that crop diversification reduces the risk of crop failure, thereby making farms less vulnerable to food shortage. Mixed cropping, which is found relatively more frequently in the ecological sys-tem, enhances bio-diversity, in terms of both habitat structure and species, and soil quality and helps to control pests and diseases.

Joshi et al. (2007) and Kumari et al. (2010) defined crop diversification as a strategy. They stated that it is considered as a strategy of reducing the reported problems. It is also considered as an effective approach to utilize scarce land and valuable water resources, and it makes agriculture sustainable and environment friendly.

Again, Mukherjee (2012) found different advantages of crop diversification in his study. He found that it also offers higher labour productivity, optimizes use of resources and utilizes the land efficiently.

De and Bodosa (2014) stated crop diversification in their study as a socially beneficial policy can be complimented by extensive infrastructural facilities, financial and technological support, etc. especially for the localized micro (labour-intensive) enterprises that are engaged in processing, storing, grading and packaging activities.

Malik and Singh (2002) studied extent of crop diversification. In this purpose they used Entropy index of crop diversification. They concluded that availability of market, increased demand of crops, export facilities and proximity to town area facilitate crop diversity whereas absence of proper market, price variability and irrigation facility are the notable hindrances for crop diversification.

Haque and Bhattacharya (2010) used Simpson's index of crop diversification by using 2010-11 data and found that the value of Simpson index is the highest in Orissa (0.25) followed by Bihar (0.18), West Bengal (0.16), Uttar Pradesh (0.15), and Jharkhand (0.08).

Rao et al. (2006) observed that lack of access to markets; transport facilities and post-harvest infrastructure inflate the transaction costs of marketing, which discourage farmers to diversify towards high value agriculture.

Again, Zohir (1993) noted that the constraints on the way of crop diversification are: established soil condition; flood depth levels; lower rainfall; lack of proper training on non- rice crops, inappropriate water management, and inadequate supply of water.

2.3.9 Use of Climate-Smart Agricultural Technologies and Practices

FAO (2012) conducted a research on the future of sustainability. It found that agricultural practices and investments must shift toward "climate-smart" systems that are more resilient to climate change and environmental variability while simultaneously reducing emissions and sequestering carbon in multiple components of farming systems and agricultural landscapes. Climate-smart principles can and must be applied and adapted to the full range of small-, medium-, and large-scale agricultural production systems.

Tegtmeier and Duffy (2004) in their study, emphasized on better use of resources and technologies. According to their study, a better concept than extensive is one that centres on intensification of resources, making better use of existing resources (e.g. land, water, biodiversity etc.) and technologies.

Environment Agency (EA) (2005) stated in their study that many other farmers have adopted integrated farming practices, which represent a step or several steps towards sustainability. What has become increasingly clear is that many modern farming systems are wasteful, as integrated farmers have found they can cut down many purchased inputs without losing out on profitability.

Bawden (2005) and Chambers (2005) found in their study that although many resource-conserving technologies and practices are currently being used, the total number of farmers using them worldwide is still relatively small. This is because their adoption is not a costless process for farmers. They cannot simply cut their existing use of fertilizer or pesticides and hope to maintain outputs, thus making operations more profitable. They also cannot simply introduce a new productive element into their farming systems and hope it would succeed. These transition costs arise for several reasons. Farmers must first invest in learning.

Sayadi et al. (2005) carried out a research on avocado growers. According to their study, in recent years, several technological innovations have been adopted by avocado growers, some of which favour the environmental sustainability of the crop.

2.4 Conceptual Framework of the Study:

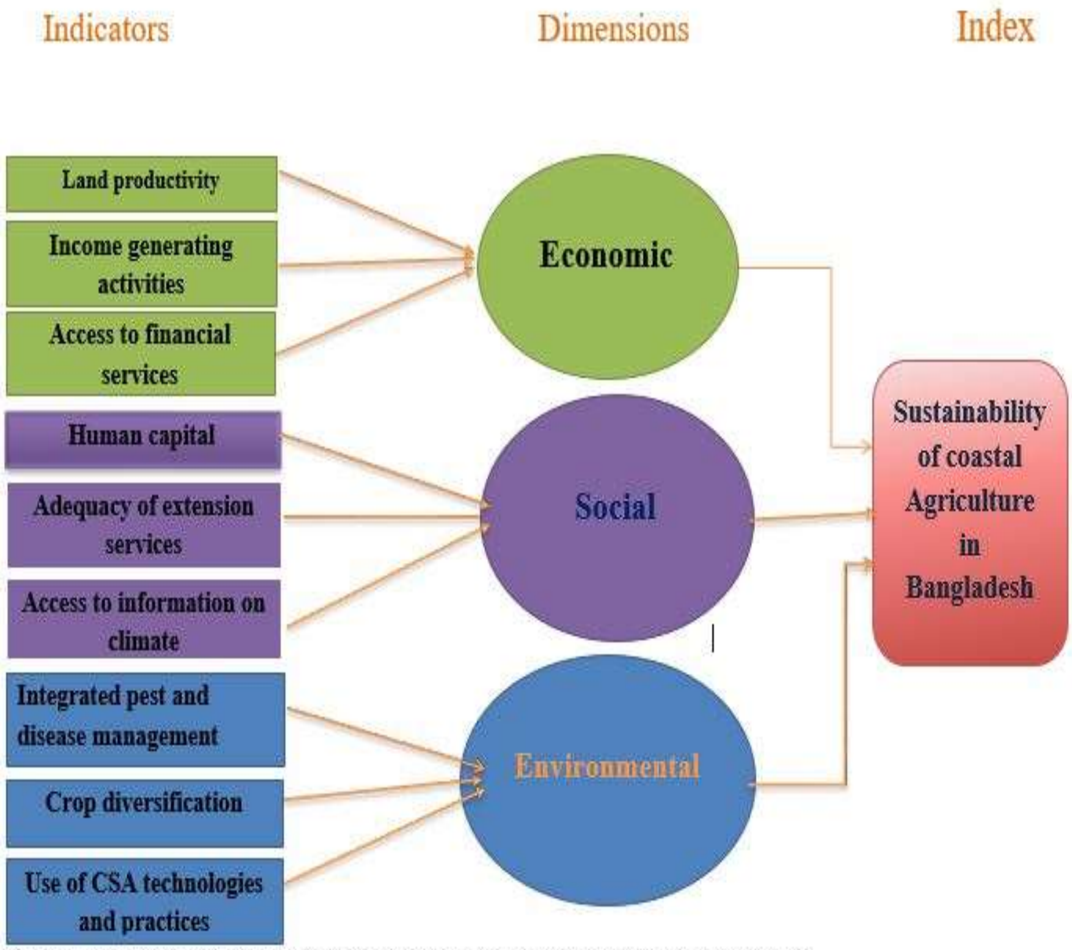

Fig. 2.1 Conceptual Framework of Assessing Sustainability of Coastal Agriculture

CHAPTER III

MATERIALS AND METHODS

Assessment of agricultural sustainability is a complex task, involving many factors. This Chapter deals with the presentation of the methods and procedures conducted in the research work. Wellington and Szczerbinski (2007) define methodology as the activity of choosing, reflecting upon, evaluating, and justifying the methods you choose. A reflection of the relationship between strategy of inquiry and specific methods can help the researcher translate approach into practice. This chapter explains in detail the methodology that guided the research. In any scientific research, methodology plays an important role and requires a very careful consideration. Appropriate methods are required to get accurate research. Therefore, methodology should be appropriate so that the researcher will be able to collect necessary data and analyse them in a proper way, which will help him to reach correct decision. Considering this, the researcher went through previous studies, obtained from supervisors and experts regarding all aspects of this piece of the study. A sequential description of the methodologies followed in conducting this research work has been presented in this chapter.

3.1 Locale of the Study

Coastal region of Bangladesh is the targeted area of the research. So, some coastal areas of the southern part of Bangladesh were selected for the study. The study was conducted in purposively selected three Upazillas namely Gournadi, Dumki and Nesarabad under Barisal, Patuakhali and Pirojpur district respectively. Two villages from each of the Upazilla as such Illah and Kamlapur under Gournadi Upazilla, Satani and Jalisha under Dumki Upazilla, Bisnukati and Gonoman under Nesarabad Upazilla, in total six villages were also purposively selected as the locale of the study as these areas are very much famous of producing agricultural crops. The map of Bangladesh showing the coastal regions appears in the Figure 3.2. The maps of selected districts showing locale of the study Upazillas are shown in Figure 3.3 to 3.5.

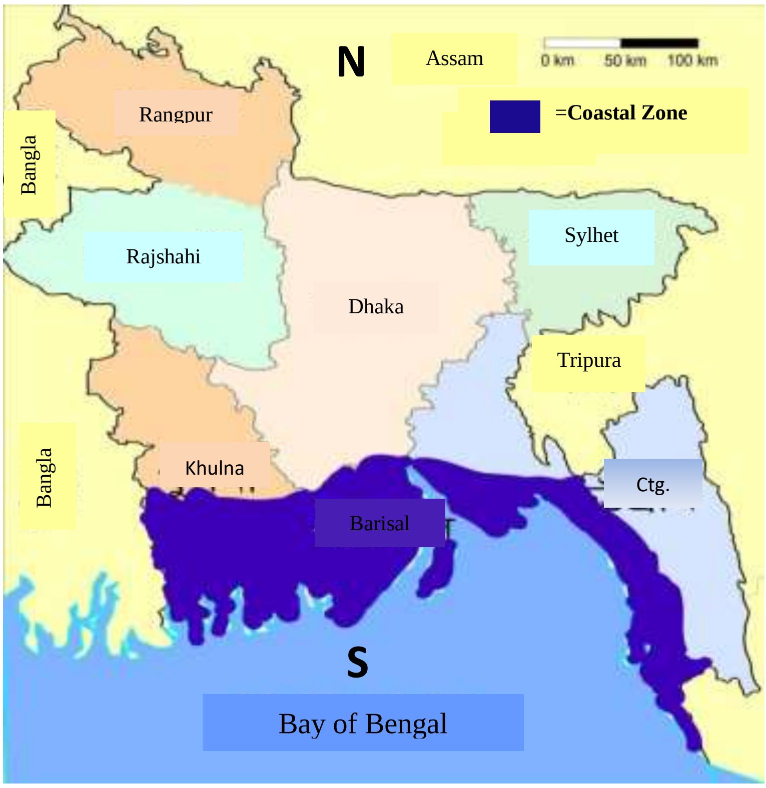

Fig.3.1 Map of Bangladesh showing coastal region

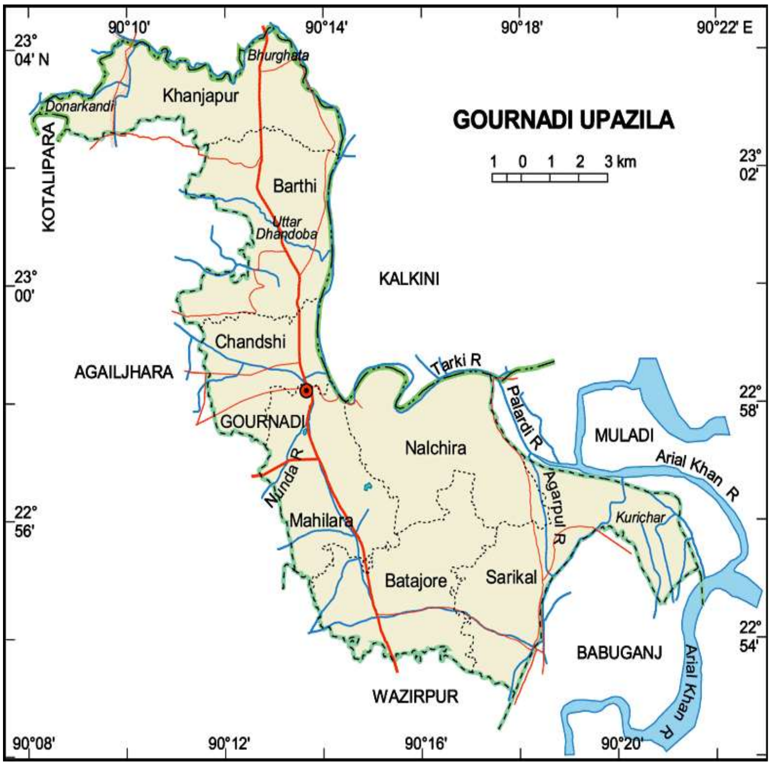

Fig.3.2 Map of Gournadi upazilla

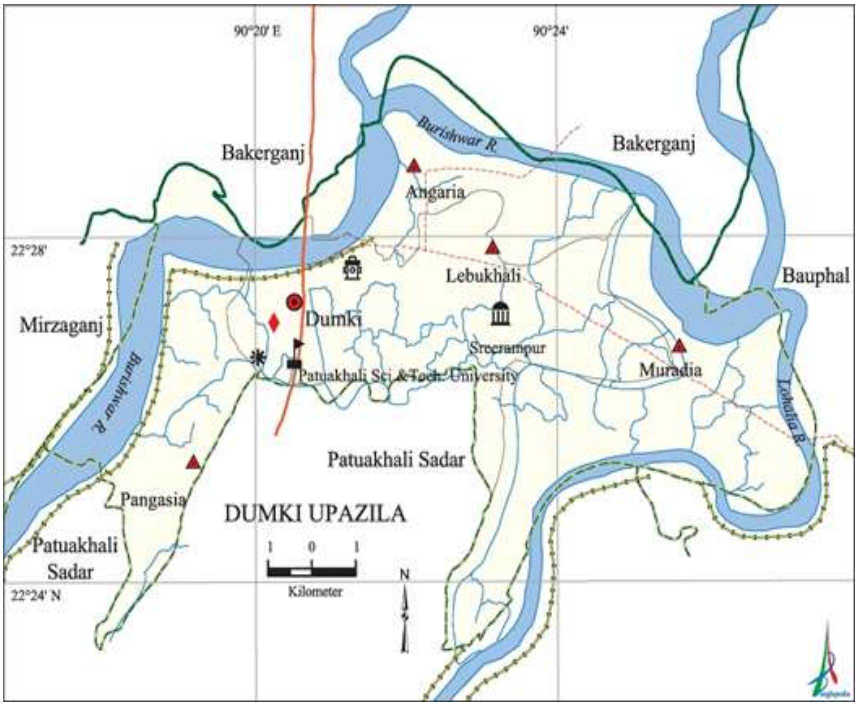

Fig.3.3 Map of Dumki upazilla

Fig.3.4 Map of Nesarabad upazilla

3.2 Population and Sample of the Study

Considering the time, financial resources and other constraints, data were collected from a sample rather than the entire population. A total of 3568 coastal farm families were listed which constituted the population of this study. For proportionate representation 120 coastal farmers were selected as the sample of the study by using Yamane's (1967) formula from the six villages. A reserve list of 20 farmers was also prepared for use in case of unavailability of the respondents for any reason. The distribution of the population, the number of sample size and number of respondents are given in the following Table 3.1.

Yamane's (1967) formula for study group:

$$n = \frac{N}{1+N\,(e)^2}$$

Where,

n = Sample size;

N, Population size = 3568;

e, the level of precision = 9%; and

The sample size (n) is = 120.

Table 3.1 Population and sample of the study

Serial Number	**District**	**Upazilla**	**Village**	**Total Number of**		**Reserve List Size**
				Farm families	Sample	
1	Barisal	Gournadi	Illah	303	10	2
			Kamlapur	947	32	5
2	Patuakhali	Dumki	Satani	580	20	3
			Jalisha	710	23	4
3	Pirojpur	Nesarabad	Gonoman	313	11	2
			Bisnukathi	715	24	4
Total:				3568	120	20

3.3 Data Collecting Instrument

In order to collect relevant information from the respondents, a previously structured interview schedule was prepared considering the objectives of the study. Simple and direct questions and different scales were used to obtain information. Both open and closed form questions were designed to obtain information relating to qualitative variable which was finally be measured by ranking score. The interview schedule was pre-tested in actual field situations before using the same for final data collection. Necessary correction, modification and adjustment were made in the interview schedule on the basis of results of pre-test. The interview schedule was then printed in its final form. An interview schedule in English version has been presented in Appendix- A. Various documents of the Government and NGOs were acted as major sources of secondary data.

3.4 Data Collecting Procedure

Farmers were the source of primary data. General discussions were held with them to monitor the situation. After that, the researcher himself through face-to-face interview collected data from selected respondents. The researcher made all possible efforts to establish rapport with the respondent so that they could feel ease and comfort to response the questions in the schedule. Necessary steps were taken to explain the purpose of the study to the respondents and their answers were recorded sincerely. The questions were explained and clarified whenever any respondent felt difficulty in understanding properly. He obtained excellent cooperation from the respondents and others concerned during the time of interview. The entire process of collecting data took place during April 2017.

3.5 Selection of the Variables of the Study

In a descriptive social research, selection and measurement of the variables is an important task. In this connection, the researcher reviewed literature as far as possible to widen his understanding about the nature and scope of the variables relevant to his research. Many scholars have dealt with the design of indicators for gauging agricultural sustainability. It was observed that the design of an appropriate set of indicators is a crucial and complex problem (Bossel, 2001) as indicators should provide a representative picture of sustainability.

Crabtree and Bayfield (1998) discussed about the indicators of sustainability. The indicators have to be based on an understanding of the pressures on the environment and the processes through which human activity induces environmental change. Rasul and Thapa (2003) also discussed the applicability of the indicators. Their study showed that although a large number of indicators have been developed, they do not cover all dimensions. Due to variation in biophysical and socioeconomic conditions, indicators used in one country are not necessarily applicable to other countries. Selection of inappropriate and inconsistent type of variables may lead to the misleading and unfruitful results. The researcher keeping all these in mind took adequate measurement in selecting the dependent and independent variables of the study. Before setting the variable of the study, the researcher himself visited the study area and talked to the farmers and he was able to observe the selected characteristics of the farmers (in the study area). Based on this experience, review of literature, discussion with the relevant experts and academicians and also with the research supervisor, the researcher selected 9 independent variables. The variables or indicators were selected under three dimensions. The selected indicators are:

Table: 3.2: Name of the Selected Indicators

Social Dimension	**Economic Dimension**	**Environmental Dimension**
Human Capital	Land Productivity	Integrated Pest and Disease management
Adequacy of Extension Services	Income Generating Activities	Crop Diversification
Access to Information on Climate and Farming practices	Access to Financial services	Use of Climate-Smart Agricultural Technologies and Practices

3.6 Measurement of Variables

In this study, an indicator-based procedure is used to assess agricultural sustainability in the coastal zones of Bangladesh; supported by descriptive data obtained by various types of primary and secondary data. Measurement of the selected indicators or variables is an important part of the study. Measurement should be in line with the objectives of the study. The researcher went through some procedures to measure the variables. The measurement procedures followed for measuring each of the variables are presented below:

3.6.1 Measurement of Variables/Indicators

The selected characteristics of the respondent farmers constituted the independent variables of the study. To keep the research within the manageable sphere, 9 independent variables were selected for the study. The procedures of measurement of the selected variables were as follows:

Land Productivity

It is the measure of the physical yield of rice per unit area and yield data (HYV and local rice) was collected by survey. The yield was converted into price (TK).

Income generating activities

This indicator explores what types of income sources the respondent has. The farming and non-farm activities that may contribute to the family income are counted from the list. 1= for each type of source. Income generating activities are measured by the total number of livelihood options the respondent possesses. For example, ‘’0’’ indicates no source of income and ‘’16’’ indicates there are 16 types of options he has.

Access to financial services

Access to financial services refers to the support received by the respondent. It is measured based on different financial sources. In this case, 2= “Sustained access”, 1=” Intermittent access” and 0=”No access”. Then it was determined by adding up all the scores for all the responses of the items of that respondent. Access to financial services could range from 0 to 20, where ‘’0’’ indicates no access and ‘’20’’ indicates maximum access to the financial services.

Human capital

This indicator explores and measures farmer’s knowledge, skills, and capacities for innovation in conventional and modern farming systems. For each category: 4 = ‘definitely’; 3 = ‘probably’; 2 = ‘probably not’; 1 = ‘not sure’ and 0 = ‘definitely not’. Human capital was determined by adding up the scores obtained by the respondent.

Human capital score could range from 0 to 48, while 0 indicating the least capacity and 48 indicating very high capacity of the respondent.

Adequacy of extension services

This indicator is quantified by asking the extent of extension contact made by the respondent to personnel, and vice versa in the last year. Scores of the responses are assigned as 0, 1, 2, 3 respectively. Where, 3 = '4 times and above'; 2 = '2–3 times'; 1 = 'one time'; and 0 = 'no visit'. Its score could range from 0 to 12. ''0'' indicates no visit and ''12'' indicates highest visit.

Access to information on climate and farming practices

It reveals whether the respondent is aware of climate changes or not and it is measured by the number of changes he noticed in last year from a list of changes. Again, over the last ten years if he observed any changes relating to the weather or not. In case of farming practice, it indicates the respondent`s access to faming related information. Then it is measured by the number of ways he uses to get that information. Here, 1=''positive response'' and 0=''negative response''. Again, the access was determined by adding up the total scores he received. The score could range from 0 to 26 while, ''0'' indicates the least consciousness and ''26'' indicates maximum consciousness.

Integrated Pest and Disease Management (IPDM)

Based on significance, knowledge and usefulness, this indicator determines whether or not she/he applied chemical and non-chemical measures in pest and disease management in the last year. For each variable: 1 = 'yes' and 0 = 'no'. If yes, then we used a 3-points Likert scale in which scores from 1 (minimum) to 3 (maximum) were used to measure the extent of significance, knowledge and use of non-chemical measures in managing pests and diseases. Then it is determined by adding up the scores he received. The score could range from 0 to 22, where ''0'' reveals no use of IPDM and ''22'' reveals maximum use of IPDM.

Crop Diversification

The study has computed the level crop diversification in the coastal area of Bangladesh. To measure the level of crop diversification there are different types of measurement index like Simpson index, Entropy index, Herfindahl index, Ogive index etc. Here, crop diversification was measured as the total number of crops and the proportion of acreage of the crop to total cropped area in the last year, using Herfindahl Index (HI) and Transformed Herfindahl Index (THI) (Velavan and Balaji, 2012).

Herfindahl index was used to study the extent of diversification in the study area. Herfindahl index is defined as: $HI=\sum Pi^2$

Pi = Proportion of area under i th crop and $Pi = Ai / \sum Ai$, In which Ai=Area under ith crop and $\sum Ai$ = Total cropped area.

The value of HI index varies between 'zero' to 'one'. It is one in case of perfect specialization and 'zero' in case of perfect diversification.

The THI is defined by THI = 1-HI

Its value increases with the increase in diversification and assumes 0 value in case of perfect diversification.

Use of Climate-Smart Agricultural Technologies and Practices

The indicator signifies how frequently farmers use selected ecologically sound practices and technologies. The scores are assigned as 0, 1, 2, 3, and 4 respectively. For all categories of use: 4 = 'adequately'; 3 = 'moderately'; 2 = 'no opinion'; 1 = 'rarely' and 0 = 'never'**.** The sum of the total score reveals the extent of using climate smart agricultural practices by the respondent. Here, the score could range from 0 to 37 while ''0'' indicating no use and ''37'' indicating maximum use.

3.7 Data Processing and Analysis

3.7.1 Processing of Data

After completion of field survey, data from all the interview schedules were coded, compiled, tabulated and analysed in accordance with the objectives of the study. In this process, all responses in the interview schedule were given numerical coded values. Local units were converted into standard units and qualitative data were converted into quantitative data by assigning suitable scores whenever necessary. The responses of the questions in the interview schedule were transferred to a master sheet to facilitate tabulation. Then, for describing the different characteristics and their use of technologies, the respondents were classified into several categories.

3.7.2 Analysis of Data

The analysis was performed using SPSS (Statistical Package for Social Sciences) computer package. Descriptive analyses such as range, number, percentage, mean, standard deviation were used whenever possible. Pearson's Product Moment Coefficient of Correlation (r) was used in the order to explore the relationship between the concerned variables.

3.7.3 Constructing Sustainable Coastal Agriculture Index

There are different methods of constructing a composite index. Here, three steps have been followed for constructing a sustainable coastal agriculture index. The steps are normalisation, weighting and aggregation. The steps are discussed below.

Normalisation: Indicators measured using a scale is normalized by applying the min-max method. This method transforms all values to scores ranging from 0 to 1by subtracting the minimum score and dividing it by the range of the indicator values.

The following formula is used to apply min-max:

$$X_i\,(_{0\ to\ 1}) = \frac{X_i - X_{Min}}{X_{Max} - X_{Min}}$$

Where

X_i= represents the individual data point to be transformed,

X_{Min}= the lowest value for that indicator,

X_{Max}= the highest value for that indicator, and

X_i= 0 to1 the new value you wish to calculate, i.e. the normalized data point within the range of 0 to 1.

Weighting and Aggregation: Equal weighting is the method most commonly used in social science research. Therefore, this study used equal weighting. For aggregating individual indicators into composite indicators, the Vulnerability Sourcebook recommends a method called ‘weighted arithmetic aggregation’. This is a common, simple and transparent aggregation procedure. Individual indicators are multiplied by their weights, summed and subsequently divided by the sum of their weights to calculate the composite indicator (CI) of a vulnerability component, as indicated in the following,

$$CI = \frac{(I_1 * w_1 + I_2 * w_2 + ... In * w_n)}{\sum^{n} w1}$$

Where, *CI* is the composite indicator, *I* is an individual indicator of a vulnerability component and *w* is the weight assigned to the indicator. If equal weighting applies, indicators are simply summed and divided by the number of indicators. Assigning a weight of 2 (or 3) to 1 or more indicators implies that these indicators are twice (or three times) important than the indicator which retains a weight of 1.

3.8 Composite Index of Coastal Sustainability:

Sustainability is a dynamic concept and varies in time and space. Its assessment using indicators has considerable shortcomings. A particular difficulty lies in the interpretation of the whole set of indicators. This makes the concept difficult to communicate to the public, policy makers, and the media. This is where a composite indicator (CI) is reasonably justifiable. The CI is increasingly recognised as a useful tool for evaluating complex and sometimes vague and elusive concepts such as sustainability (Esty et al. 2005) environmental performance (Emerson et al. 2010) and policy analysis (Brand et al. 2007). Generally, a CI is the mathematical combination of individual indicators based on an underlying model, taking into consideration methodological assumptions and subjective as well as objective judgements. Moreover, expert-led indicator development with active participation of local stakeholders is recognised for consolidative assessment (Roy and Chan 2011). In the present study, an assemblage of top-down and bottom-up approaches was adopted for the development of an essential set of 9 indicators.

The three dimensions were recognized the broad scope of agricultural sustainability —the dimensions are:

i) Social dimension: eg. human capital, Extension Contacts, Access to information etc.
ii) Economical dimension: eg. land Productivity, Access to financial services etc.
iii) Environmental dimension: eg. use of IPDM, use of climate smart technologies etc.

3.9 Theoretical framework for indicator generation

Sustainability indicators are the indicators those provide information, directly or indirectly, about the future viability of specified levels of social objectives such as material welfare, environmental quality, and natural amenity. Many scholars have dealt with the design of indicators for gauging agricultural sustainability. It was observed that the design of an appropriate set of indicators is a crucial and complex problem (Bossel, 2001), as indicators should provide a representative picture of sustainability. Stockle et al. (1994) proposed a framework for evaluating the relative sustainability of a farming system using nine attributes; productivity, profitability, soil quality, water quality, air quality, energy efficiency, fish and wildlife habitat, quality of life and social acceptance. They recommended scoring based on quantifiable constraints within each attribute. Other evaluation techniques such as expert opinion and computer simulation models were also suggested, if direct measurement is not possible.

The work of Roy et al. (2013) can be referred to for more methodological details. Table 3.2 presents a description of the indicators and their measurement, as well as the objectives of each dimension. Figure 3.9 provides an illustration of the methodology employed for the construction of a composite indicator in study.

Table 3.3 Indicators definition and measurement, including objective of the dimensions			
Dimension and objective	**Indicators**	**Definition and measurement**	**Source**
Economic: to achieve economic viability	Land Productivity	It is the measure of the physical yield of rice per unit area and yield data (HYV and local rice) was collected by survey. The yield is converted into price (TK).	Following Rasul and Thapa (2004)
	Income generating activities	This indicator explores what types of income sources the respondent has. The farming and non-farm activities that may contribute to the family income are counted from the lists. 1= for each type of source.	Following FAO (1998)
	Access to financial services	Access to financial services refers to the support received by the respondent. It is measured based on different financial sources. In this case, 2= “Sustained access”,1=” Intermittent access” and 0=”No access”	Following Roy et al. (2013)
Social: to enhance the quality of life of the society at large	Human capital	This indicator explores and measures farmer’s knowledge, skills, and capacities for innovation in conventional and modern farming systems. For each category: 4 = ‘definitely’; 3 = ‘probably’; 2 = ‘probably not’; 1 = ‘not sure’ and 0 = ‘definitely not’	Following Roy et al. (2013)
	Adequacy of extension services	This indicator is quantified by asking the extent of extension contact made by the respondent to personnel, and vice versa in the last year. 3 = ‘4 times and above’; 2 = ‘2–3 times’; 1 = ‘one time’; and 0 = ‘no visit’.	Following Zhen et al. (2005)

	Access to information on climate and farming practices	It indicates whether the respondent is aware of climate changes or not and it is measured by the number of changes he noticed in last year from a list of changes. Again, over the last ten years if he observed any changes relating to the weather or not. In case of farming practice, it indicates the respondent`s access to faming related information. Then it is measured by the number of ways he uses to get that information. Here,1=’’positive response’’ and 0=’’negative response’’.	Following Gowda and Jayaramaiah (1998)
Environmental: : to maintain and improve the natural resource base	Integrated Pest and Disease Management	Based on significance, knowledge and usefulness, this indicator measures whether or not they applied chemical and non-chemical measures in pest and disease management. For each variable: 1 = ‘yes’ and 0 = ‘no’. If yes, then we used a 3-points Likert scale in which scores from 1 (minimum) to 3 (maximum) were used to measure the extent of significance, knowledge and use of non-chemical measures in managing pests and diseases.	Following Roy et al. (2014)
	Crop Diversification	Measured as the total number of crops and the proportion of acreage of the crop to total cropped area in the last year, using Herfindahl Index (HI) and Transformed Herfindahl Index (THI).	Velavan and Balaji (2012).
	Use of Climate-Smart Agricultural Technologies and Practices	The indicator signifies how frequently farmers use selected ecologically sound practices and technologies. For all categories of use: 4 = ‘adequately’; 3 = ‘moderately’; 2 = ‘no opinion’; 1 = ‘rarely’ and 0 = ‘never’	Based on Pretty et al. (2006)

Steps followed in indicator selection process:

Step 5: Index calculation, internal consistency and robustness checking, presentation and discussions

↑

Step 4: Conduct three central step of index development
Normalisation (max-min method), weighting (equal weighting), aggregation (linear)

↑

Step 3: Data screening and multivariate analysis
-Conduct data screening test: outliers checking
- Study the overall structure and suitability of the dataset for subsequent methodological choices like weighting and aggregation

↑

Step 2: Field survey and calculation indicators
-Design of questionnaire and reconnaissance of home visit
-Checking and getting completion data set

↑

Step 1: Theoretical foundation and indicator generation
Develop indicators using literature review, expert's opinion

Fig. 3.9 Methodology employed for the construction of the composite indicator (CI) in the study

CHAPTER IV
FINDINGS AND DISCUSSION

Findings and discussion is the central point of the whole research work. The purpose of this chapter is to describe the findings of the study. The research quality depends upon how well the findings of the research are interpreted. Procedures of using data for the measurement needed some discussion for clarity of understanding. Data obtained from respondents by interview were measured, analyzed, tabulated and statistically treated according to the objectives of the study. This chapter has been discussed in five sections such as 1. Selected characteristics of the respondents, 2. Characteristics of sustainability of Coastal Agriculture Index and 3. Correlation coefficients for the coastal agricultural sustainability index and its dimensions etc.

4.1 Selected Characteristics of the Coastal Farmer

Behavior of an individual is determined to a large extent by his personal characteristics. More particularly, the characteristics of an individual play a vital role in developing mental make up for making decisions about various issues in his life. Moreover, decisions related to farming activities are being influenced largely by different characteristics of an individual. The characteristics of the coastal farmers were selected to find out their relationship with the sustainability of coastal agriculture. The selected characteristics included land productivity, income generating activities, access to financial services, human capital, adequacy of extension services, access to information on climate and cropping practices, integrated pest and disease management, crop diversification and use of climate smart agricultural technologies and practices. These characteristics of the farmers have been described in this section.

To check that a distribution of scores is normal, we need to look at the values of kurtosis and skewness. The values of skewness and kurtosis should be zero in a normal distribution. Positive values of skewness indicate a pile-up of scores on the left of the distribution, whereas negative values indicate a pile-up on the right. Positive values of kurtosis indicate a pointy and heavy-tailed distribution, whereas negative values indicate a flat and light-tailed distribution. The further the value is from zero, the more likely it is that the data are not normally distributed. The assumption of normality is important in research using regression analysis (Field, 2009), for which, skewness and kurtosis value was estimated (Table 4.1).

The salient features of individual characteristic of the farmer are shown in the table 4.1 below.

Table 4.1 Salient features of the farmers selected characteristics

Characteristics	Measuring units	Range		Skewness	Kurtosis
		Possible	Observed		
Land Productivity	Taka	-	400-640	-.069	-.632
Income generating activity	Score	-	2-7	-.128	-.465
Access to financial services	Score	0-17	3-12	.180	-.902
Human Capital	Score	12-60	41-53	-.748	1.089
Adequacy of extension services	Score	0-12	2-6	.097	-.820
Access to information on climate and cropping pattern	Score	0-26	8-14	.083	-.809
Integrated pest and disease management	Score	0-22	9-16	-.054	-.649
Crop Diversification	Score	-	0.40-0.68	-.505	.633
Use of climate smart agricultural technologies and practices	Score	0-41	17-30	-.452	.237

4.1.1 Land productivity

Land productivity scores of the respondents in the study area ranged from 400 to 640 with an average of 504.75 and standard deviation 60.70. The respondents have been classified into three categories (Mean ± Standard Deviation) on the basis of their land productivity scores. The categories are shown in the table 4.2 below.

Table 4.2 Distribution of the respondents according to land productivity

Categories	Respondents		Mean	SD
	Number	Per cent		
Low Productivity (up to 450)	25	20.8	504.75	60.70
Medium Productivity (451-550)	61	50.8		
High Productivity (above 550)	34	28.4		
Total	120	100		

Data furnished in the above table (4.2) indicate that the highest number (50.8%) of respondents lie in the medium category compared to 20% in low productivity and 28% in high productivity. It shows that about four fifth of the respondents had medium to higher land productivity. Farmers with higher land productivity are more sustainable. Golam Sarwar et al. (2013) and Uphoff (2002) found more or less the same findings in their study.

4.1.2 Income generating activities

Income generating activity scores of the respondents ranged from 2 to 7 with an average of 4.36 and standard deviation 1.10. According to the scores of income generating activities the respondents have been classified into three categories (Mean ± Standard Deviation) such as low (<3), medium (4-5) and high (>5). The categories are shown below in the table 4.3

Table 4.3 Distribution of the respondents based on their income generating activities

Categories	Respondents		Mean	SD
	Number	Per cent		
Low Income generating activity (up to3)	25	20.8	4.36	1.10
Medium Income generating activity (4-5)	75	62.5		
High Income generating activity (above 5)	20	16.7		
Total	120	100		

Data presented in the above table (4.3) reveals that maximum proportion of the respondents had medium (62%) income generating activities where only 16.7% had higher and 20.8% had low income generating activities. People with higher number of income generating activities have the capacity to earn more and are more sustainable. Here about two third of the respondents had medium income generating activities.

4.1.3 Access to financial services

Access to financial services scores of the respondents ranged from 3 to 7 with an average of 5.25 and standard deviation 1.05. The respondents have been classified into three categories on the basis of their access to financial services scores. The categories are shown in the table 4.4 below.

Table 4.4 Distribution of the respondents based on their access to financial services.

Categories	Respondents		Mean	SD
	Number	Per cent		
Low access to financial services (up to 4)	33	27.5	5.25	1.05
Medium access to financial services (5-6)	69	57.5		
High access to financial services (above 6)	18	15		
Total	120	100		

The findings presented in the above table (4.4) illustrate that the highest proportion (57.5%) of the respondents belongs to medium level of access to financial services category while 27.5% respondents had low access and 15% had high access. It shows that only a small number of farmers in the study area had frequent access to financial services. On the other hand, four fifth of the respondents had low to medium access to financial services.

4.1.4 Human capital

Human capital scores of the respondents ranged from 41 to 53 with an average of 48.11 and standard deviation 2.25. According to the human capital scores, the respondents have been classified into three categories. The categories are shown in the table 4.5 below.

Table 4.5 Distribution of the respondents according to human capital

Categories	**Respondents**		**Mean**	**SD**
	Number	**Per cent**		
Low Capacity (up to 45)	14	11.6	48.11	2.25
Medium Capacity (46-50)	90	75		
High Capacity (above 50)	16	13.4		
Total	120	100		

Data furnished in the above table (4.5) describe that the highest proportion of the respondents had medium level of knowledge, skill and capacity while only a few had low and high human capital with 11.6% and 13.4% respectively. Here, three fourth of the respondents cover medium level of human capital. As human capital is an important factor of sustainability, it is needed to increase their human capital. Pretty et al. (2006) observed the same findings in his study.

4.1.5 Adequacy of extension services

Adequacy of extension services scores of the respondents ranged from 2 to 6 with an average of 3.57 and standard deviation 1.03. The respondents have been classified into three categories on the basis of their land productivity scores. The categories are shown in the table 4.6 below.

Table 4.6 Distribution of the respondents based on the adequacy of extension services

Categories	**Respondents**		**Mean**	**SD**
	Number	**Per cent**		
Low Adequacy of extension Services (up to 2)	20	16.7	3.57	1.03
Medium Adequacy of extension Services (3-4)	75	62.5		
High Adequacy of extension Services (above 4)	25	20.8		
Total	120	100		

According to the above table (4.6) we get a clear view that majority of the respondents (62%) in the study area had medium access to extension services where 16.7% of the respondents had low access and 20.8% had high adequacy of extension services. The picture reveals that most of the farmers (about 80%) of that area had medium to high access to extension services. Ommani et al. (2008) and Leeuwise and Van den Ben (2004) found similar result in their respective study.

4.1.6 Access to information related on climate and cropping practices

Access to information related on climate and cropping practices scores of the respondents ranged from 8 to 14 with an average of 10.66 and standard deviation 1.67. Based on their scores the respondents have been classified into three categories such as low access (<9), medium access (10-12) and high access (>12). The categories are shown in the table 4.7 below.

Table 4.7 Distribution of the respondents according to their access to information related to climate

Categories	**Respondents**		**Mean**	**SD**
	Number	**Per cent**		
Low (up to 9)	32	26.7	10.66	1.67
Medium (10-12)	69	57.5		
High (above 12)	19	15.8		
Total	120	100		

From the above table (4.7), we see that respondents of the study area had variety of access to information related to climate and cropping pattern. Here, a plenty of people (57.5%) had medium access to climate information while 26.7% had low access and only 15.8% of the respondents had frequent access to climate information.

4.1.7 Use of integrated pest and disease management

Use of integrated pest and disease management scores of the respondents ranged from 9 to 16 with an average of 12.60 and standard deviation 1.82. According to the use of IPDM scores of the respondents, they have been classified into three categories. The categories are shown in the table 4.8 below.

Table 4.8 Distribution of the respondents according to their use of integrated pest and disease management.

Categories	**Respondents**		**Mean**	**SD**
	Number	**Per cent**		
Low use of IPDM (up to 10)	17	14.2	12.6	1.82
Medium use of IPDM (11-14)	83	69.1		
High use of IPDM (above 14)	20	16.7		
Total	120	100		

Data presented in the above table (4.8) reveal that majority of the respondents in the study area belongs to the medium category (69.1%) while only 14.2% of the respondents used integrated pest and disease management and 16.7% used IPDM. Integrated pest and disease management helps in attaining agricultural sustainability. Akter (1997) and Dufour (2001) found similar findings in their study.

4.1.8 Crop diversification

Crop diversification scores of the respondents ranged from 0.40 to 0.68 with an average of 0.58 and standard deviation 0.05. The respondents have been classified into three categories (Mean ± Standard Deviation) on the basis of their land productivity scores such as low, medium and high. The categories are shown in the table 4.9 below.

Table 4.9 Distribution of the respondents according to crop diversification

Categories	Respondents		Mean	SD
	Number	Per cent		
Low Crop diversification (up to 0.52)	19	15.8	0.58	0.05
Medium Crop diversification (0.53-0.63)	84	70.1		
High Crop diversification (above 0.63)	17	14.1		
Total	120	100		

Data furnished in the above table (4.9) show that the highest proportion of the respondents (70.1%) belongs to the medium category compared to 15.8% low and 14.1% high category. Low and high categories had almost the same proportion of the respondents. It indicates that most of the farmers of the study area follow medium level of crop diversification. Kumari et al. (2010) found more or less similar findings.

4.1.9 Use of climate smart agricultural technology and practices

Scores of the respondents on use of climate smart agricultural technology and practices ranged from 17 to 30 with an average of 24.73 and standard deviation 2.61. On the basis of the use of CSA technology and practices scores, the respondents have been classified into three categories. The categories are shown in the table 4.10 below.

Table 4.10 Distribution of the respondents according to their use of climate smart agricultural technologies and practices

Categories	Respondents		Mean	SD
	Number	Per cent		
Low Use of CSA technology and practices (up to 23)	34	28.4	24.73	2.61
Medium Use of CSA technology and practices (24-27)	70	58.2		
High Use of CSA technology and practices (above 27)	16	13.4		
Total	120	100		

Findings of the above table describe that maximum proportion of the respondents (58.2%) use a medium level climate smart agricultural technologies and practices where only a small number of respondents belongs to the high category with 13.4% and 28.4% have fallen under low category. This picture reveals that medium category had the highest and high category had lowest proportion of respondents.

4.2 Characteristics of Sustainability of Coastal Agriculture Index:

Sustainability of coastal agriculture index is made up of 9 variables and some specific measures like normalization, weighting and aggregation and multiplied by 100 which are arranged under the 3 dimensions of sustainability: economic, social and environmental. All these nine variables may be termed as indicators of sustainability of coastal agriculture. They reveal the sustainability of coastal agriculture in Bangladesh in different aspects. The index was measured by calculating scores of these nine variables following some formulae. The score of the developed index ranged from 30.33 to 69.95 with mean and standard deviation 49.25 and 9.41 respectively. Based on the scores, the index was classified into four categories following Royal London (2017) namely not sustainable access, moderately sustainable access, reasonably sustainable access and highly sustainable access. The distribution of the respondents has been given below (table 4.11).

Table 4.11 Distribution of the respondents based on coastal sustainability index

Categories	**Range**		**Respondents**		**Mean**	**SD**
	Score	**Observed**	**Number**	**Per cent**		
Not sustainable	≤ 35	30.33-69.95	11	9.2	49.25	9.41
Moderately sustainable	36-50		48	40		
Reasonably sustainable	51-65		39	32.5		
High sustainable	≥ 66		22	18.3		
Total			120	100.0		

Table 4.11 revealed that 40% respondents belongs to the moderately sustainable category which is the highest compared to 32% reasonably sustainable, 18% high sustainable category where 11% is the lowest for not sustainable category. The figure indicates that a good deal of coastal people have moderately to reasonably sustainable access.

4.3 Pearson's correlation coefficients between the selected indicators and Sustainability of Coastal Agriculture Index as well as their underlying dimensions:

Purpose of the study is to examine the relationship between each of the independent variables and dependent variable. The nine selected characteristics of the respondents were the independent variables of the study. The variables were land productivity, Income generating activities, access to financial services, human capital, adequacy of extension services, access to information on climate and cropping practices, integrated pest and disease management, crop diversification and use of climate smart agricultural technologies and practices. On the other hand, sustainability of coastal agriculture in Bangladesh is the dependent variable in this study. The summary of the results of the correlations co-efficient relationships between the selected characteristics of the respondents and sustainability of coastal agriculture in Bangladesh has been discussed below.

Table 4.12 Pearson's correlation coefficients between the selected indicators and sustainability index as well as their underlying dimensions

Dimensions	Indicators	Correlation with	
		Index	Dimensions
Economic	Land productivity	.394**	.580**
	Income generating activities	.306**	.391**
	Access to financial services	.051^{NS}	.188*
Social	Human capital	.189*	.461**
	Adequacy of extension services	.488**	.231*
	Access to information on climate and cropping practices	.457**	.578**
Environmental	Integrated pest and disease management	.084^{NS}	.229*
	Crop diversity	.029^{NS}	.230*
	Use of climate smart agricultural technologies and practices	.471**	.639**

NS = Non significant,

* = Significant at 0.05 level of probability, ** = Significant at 0.01 level of probability

4.3.1 Relationship between land productivity and Sustainability of Coastal Agriculture Index

The relationship between land productivity and sustainability of coastal agriculture in Bangladesh was examined by testing the following null hypothesis: "There is no relationship between land productivity and sustainability of coastal agriculture in Bangladesh." The co-efficient of correlation between the concerned variables was found to be 'r' = 0.394 as shown in Table 4.12. This led to the following observations regarding the relationship between the two variables under consideration:

• The relationship showed a tendency in the positive direction between the concern variables.

• The computed value of 'r' (0.394**) was significant at 1 per cent level of probability.

• The correlation co-efficient between the two concerned variables was significantly strong.

Based on the above findings, it was concluded that land productivity of the farmers had a significant positive relationship with the sustainability of coastal agriculture in Bangladesh as perceived by them. This represents that land productivity was an important factor in attaining agricultural sustainability in coastal Bangladesh as perceived by them. By the same way, with the increase of land productivity, sustainability of coastal agriculture in Bangladesh will also increase.

4.3.2 Relationship between income generating activities and sustainability of coastal agriculture in Bangladesh

The relationship between income generating activities and sustainability of coastal agriculture in Bangladesh was examined by testing the following null hypothesis: "There is no relationship between income generating activities and sustainability of coastal agriculture in Bangladesh." The co-efficient of correlation between the concerned variables was found to be 'r' = 0.306 as shown in Table 4.12. This led to the following observations regarding the relationship between the two variables under consideration:

• The relationship showed a tendency in the positive direction between the concern variables.

• The computed value of ‘r’ (0.306**) was significant at 1 per cent level of probability.

• The correlation co-efficient between the two concerned variables was significantly strong.

Based on the above findings, it was concluded that income generating activities of the farmers had a significant positive relationship with the sustainability of coastal agriculture in Bangladesh as perceived by them. This represents that income generating activities was an important factor in attaining agricultural sustainability in coastal Bangladesh as perceived by them. By the same way, with the increase of income generating activities of the farmers, sustainability of coastal agriculture in Bangladesh will also increase.

4.3.3 Relationship between adequacy of extension services and sustainability of coastal agriculture in Bangladesh

The relationship between adequacy of extension services and sustainability of coastal agriculture in Bangladesh was computed by testing the following null hypothesis: “There is no relationship between adequacy of extension services and sustainability of coastal agriculture in Bangladesh.” The co-efficient of correlation between the concerned variables was found to be ‘r’ = 0.488 as shown in Table 4.12. This led to the following observations regarding the relationship between the two variables under consideration:

• The relationship showed a tendency in the positive direction between the concern variables.

• The computed value of ‘r’ (0.488**) was significant at 1% level of probability.

• The correlation co-efficient between the two concerned variables was significant.

Based on the above findings, it was concluded that adequacy of extension services of the farmers had a significant positive relationship with the sustainability of coastal agriculture in Bangladesh as perceived by them. This represents that adequacy of extension services was an important factor in attaining agricultural sustainability in coastal Bangladesh as perceived by them.

4.3.4 Relationship between Access to information on climate and cropping practices and sustainability of coastal agriculture in Bangladesh

The relationship between access to information on climate and cropping practices and sustainability of coastal agriculture in Bangladesh was examined by testing the following null hypothesis: "There is no relationship between access to information on climate and cropping practices and sustainability of coastal agriculture in Bangladesh." The co-efficient of correlation between the concerned variables was found to be 'r' = 0.457 as shown in Table 4.12. This led to the following observations regarding the relationship between the two variables under consideration:

- The relationship showed a tendency in the positive direction between the concern variables.
- The computed value of 'r' (0.457**) was significant at 1 per cent level of probability.
- The correlation co-efficient between the two concerned variables was significantly strong.

Based on the above findings, it was concluded that access to information on climate and cropping practices of the farmers had a significant positive relationship with the sustainability of coastal agriculture in Bangladesh as perceived by them. This represents that access to information on climate and cropping practices was an important factor in attaining agricultural sustainability in coastal Bangladesh as perceived by them. By the same way, with the increase of access to information on climate and cropping practices, sustainability of coastal agriculture in Bangladesh will also increase.

4.3.5 Relationship between use of climate smart agricultural technologies and practices and sustainability of coastal agriculture in Bangladesh

The relationship between use of climate smart agricultural technologies and practices and sustainability of coastal agriculture in Bangladesh was examined by testing the following null hypothesis: "There is no relationship between use of climate smart agricultural technologies and practices and sustainability of coastal agriculture in Bangladesh." The co-efficient of correlation between the concerned variables was found to be ‘r’ = 0.471 as shown in Table 4.12. This led to the following observations regarding the relationship between the two variables under consideration:

• The relationship showed a tendency in the positive direction between the concern variables.

• The computed value of ‘r’ (0.471**) was significant at 1% level of probability.

• The correlation co-efficient between the two concerned variables was significant.

Based on the above findings, it was concluded that use of climate smart agricultural technologies and practices of the farmers had a significant positive relationship with the sustainability of coastal agriculture in Bangladesh as perceived by them. This represents that use of climate smart agricultural technologies and practices was an important factor in attaining agricultural sustainability in coastal Bangladesh as perceived by them. By the same way, as the use of climate smart agricultural technologies and practices increase, sustainability of coastal agriculture in Bangladesh will also increase.

4.4 Pearson’s correlation coefficients for the coastal agricultural sustainability index and its dimensions

Pearson’s correlation analysis has been done to show the relationship among the dimensions and the coastal sustainability index. The correlation coefficients of the analysis are shown below table 4.13

Table 4.13 Pearson’s correlation coefficients for the index and its dimensions

	Dimensions		
	Economic	Social	Environmental
Sustainability Index	.718**	.794**	.705**
Dimensions			
Economic	1	.408**	.325**
Social	.408**	1	.400**
Environmental	.325**	.400**	1

4.4.1 The relationship between economic dimension and coastal sustainability index

The relationship between Economic dimension and sustainability of coastal agriculture in Bangladesh was examined and the co-efficient of correlation between the concerned variables was found to be ‘r’ = 0.718 as shown in Table 4.13

This led to the following observations regarding the relationship between the two variables under consideration:

• The relationship showed a tendency in the positive direction between the concern variables.

• The computed value of ‘r’ was (0.718**) at 1% level of probability.

• The correlation co-efficient between the two concerned variables was significantly strong.

Based on the above findings, it was concluded that economic index and coastal sustainability index the farmers had a significant positive relationship as perceived by them. This represents that economic index was an important factor in attaining agricultural sustainability in coastal Bangladesh.

4.4.2 The relationship between social dimension and coastal sustainability index

The relationship between Social dimension and sustainability of coastal agriculture in Bangladesh was examined and the co-efficient of correlation between the concerned variables was found to be ‘r’ = 0.794 as shown in Table 4.13

This led to the following observations regarding the relationship between the two variables under consideration:

• The relationship showed a tendency in the positive direction between the concern variables.

• The computed value of ‘r’ was (0.794**) at 1% level of probability.

• The correlation co-efficient between the two concerned variables was significantly strong.

Based on the above findings, it was concluded that social index and coastal agricultural sustainability dimension the farmers had a significant positive relationship as perceived by them. This represents that social index was also an important factor in attaining agricultural sustainability in coastal Bangladesh.

4.4.3 The relationship between environmental dimension and coastal sustainability index

The relationship between Environmental dimension and sustainability of coastal agriculture in Bangladesh was examined and the co-efficient of correlation between the concerned variables was found to be 'r' = 0.705 as shown in Table 4.13

This led to the following observations regarding the relationship between the two variables under consideration:

• The relationship showed a tendency in the positive direction between the concern variables.

• The computed value of 'r' was (0.705**) at 1% level of probability.

• The correlation co-efficient between the two concerned variables was significantly strong.

Based on the above findings, it was concluded that environmental index and coastal agricultural sustainability index the farmers had a significant positive relationship as perceived by them. This represents that environmental index was an important factor in attaining agricultural sustainability in coastal Bangladesh. By the same way, with the increase of environmental dimension, sustainability of coastal agriculture in Bangladesh will also increase.

4.5 Interpretation of the simple regression performed in the study

For the assessment of sustainability of coastal agriculture in Bangladesh, simple regression has been used. The results of the analysis are shown below tables 4.14, 4.15 and 4.16

Table 4.14 Model Summary of the simple regression done in the study

Model	R	R Square	Adjusted R Square	Standard error of the estimate
1	.751[a]	.564	.560	6.465

Table 4.15 ANOVA of the simple regression done in the study

Model	Sum of square	df	Mean square	F	Sig.
1 Regression	5940.50	9	660.056		
Residual	4599.840	110	41.817	15.784	.000[b]
Total	10540.344	119			

Table 4.16 Simple regression coefficients of contributing factors related to assessment of coastal agricultural sustainability in Bangladesh

Developed variable	Indicators	Unstandardized Coefficient	Standardized Beta	Sig.
Coastal agricultural sustainability in Bangladesh	Land productivity	.036	.232	.001**
	Income generating activities	1.279	.150	.026*
	Access to financial services	.937	.117	.221 NS
	Human capital	.665	.159	.016*
	Adequacy of extension services	2.283	.251	.001**
	Access to information on climate and cropping practices	1.271	.225	.002**
	Integrated pest and disease management	.229	.040	.196NS
	Crop diversity	13.54	.080	.236NS
	Use of climate smart agricultural technologies and practices	.843	.135	.056*

** Significant at $p < 0.01$;

* Significant at $p < 0.05$;

4.5.1 Interpretation of the table 4.14, table 4.15 and table 4.16:

This summary table 4.14 provides the value of R and R^2 for the model that has been derived. For these data, R has a value of .751and this value represents the simple correlation between selected variables and coastal agricultural sustainability. On the other hand, the value of R^2 is .564, which tells us that the selected variables account for 56% of sustainability of coastal agriculture in Bangladesh. There might be many factors that lead to sustainable agriculture, but this model, which includes a sustainability index, which can explain approximately 56% of it. This means that 44% of the coastal agricultural sustainability cannot be explained by the selected variables. Therefore, there must be other variables that have an influence also.

The ANOVA tells us whether the results in a significantly good degree of prediction of the outcome variable or not. However, the ANOVA doesn't tell us about the individual contribution of variables in the model.

In general, values of the regression coefficient b represents the change in the outcome resulting from a unit change in the predictor and that if a predictor is having a significant impact on our ability to predict the outcome then this b should be different from 0. The beta coefficients can be negative or positive, and have a t-value and significance of that *t*-value associated with each. If the beta coefficient is not statistically significant (i.e., the *t*-value is not significant), no statistical significance can be interpreted from that predictor. If the beta coefficient is significant, examine the sign of the beta. If the regression beta coefficient is positive, the interpretation is that for every 1-unit increase in the predictor variable, the dependent variable will increase by the unstandardized beta coefficient value. Such as, Human capital (b = 0.665) indicates that as human capital increases by one unit, agricultural sustainability will increase by 0.665 units. Similarly, income generating activities (b=1.279) indicates that as advertising budget increases by one unit, record sales increase by 1.279 units. This interpretation is true only if the effects of income generating activities and agricultural sustainability are held constant.

Some important factors of coastal agricultural sustainability are shown below.

Adequacy of extension services (*b* = 0.251): This value indicates that as the number of extension contact increases by one, sustainability increase by 0.251units. This interpretation is true only if the effects of the other variables are held constant.

Access to information on climate and cropping practices (*b* =0.225): This value indicates that Access to information on climate and cropping practices increases by one unit, sustainability increase by 0.225 units. This interpretation is true only if the effects of the other variables are held constant.

Land Productivity (*b* = 0.232): This value indicates that as land productivity increases by one unit, sustainability increase by 0.232 units. This interpretation is true only if the effects of the other variables are held constant.

The *t*-tests measures whether the predictor is making a significant contribution to the model or not. Therefore, if the *t*-test associated with a *b*-value is significant (if the value in the column labelled *Sig.* is less than .05) then the predictor is making a significant contribution to the model. From the magnitude of the *t*-statistics it is seen that the land productivity, adequacy of extension services and access to information had a similar and higher impact on coastal agricultural sustainability, whereas the other variables had less impact.

4.6 Policy Implications

The findings of this study have significant policy implications for coastal agriculture and coastal farmers, which are essential for agricultural development. As per the findings of this study, policies should also pay due attention to address the major constraints of coastal agriculture. Therefore, the following overall policy implications were drawn with rationale and practical reference for attaining sustainable coastal agriculture in Bangladesh. These policies are based on three major factors those have most impact on sustainable coastal agriculture in Bangladesh.

- Increasing land productivity needs a multi-year planning and strategies. In Bangladesh, land productivity is much lowered than other countries, with limited scope for horizontal expansion of agricultural land. Hence, effective initiatives are needed to increase productivity, such as increasing irrigation coverage, providing high quality hybrid seeds, improving irrigation efficiency, minimizing yield gaps, and developing flood and salinity resistance rice varieties. World Bank (2008) recognized that increasing land productivity is one of the key strategies for improving the livelihoods of subsistence farming communities.

- Extension services play a vital role in disseminating technologies and solving farmers' problem. Farmers of the coastal areas, have a limiting access to extension services. Awareness building, rapport establishment, communication development are the ways of improving the access of the farmers to extension services which contributes in achieving agricultural sustainability.

- For achieving a sustainable coastal agriculture, improved access to timely, accurate and trustworthy climate information is essential for the coastal farmers. As agriculture is climate dependent sector, climate information helps the farmers a lot in time of crop cultivation. Open sharing of information between public entities, free accessibility of information to all may be better way of getting access to climate information.

CHAPTER V

SUMMARY OF FINDINGS, CONCLUSIONS AND RECOMMENDATIONS

The purpose of the study was to assess the sustainability of agriculture in the coastal area of Bangladesh. So, the study was conducted in purposively selected three Upazillas namely Gournadi, Dumki and Nesarabad under Barisal, Patuakhali and Pirojpur district respectively. Two villages from each of the Upazilla as such Illah and Kamlapur under Gournadi Upazilla, Satani and Jalisha under Dumki Upazilla, Bisnukathi and Gonoman under Nesarabad Upazilla, in total six villages were also purposively selected as the locale of the study. Total respondents were selected from the study area as the population and number from the three upazilas 120 respondents constituted the sample of the study. A well-structured interview schedule was developed based on objectives of the study for collecting information. The indicators were: land productivity, income generating activities, access to financial services, human capital, adequacy of extension services, access to information on climate and farming practices, integrated pest and disease management, crop diversification, use of climate-smart agricultural technologies and practices. The entire process of collecting data took place during April 2017. Various statistical measures such as frequency, percentage, mean and standard deviation were used in describing data. In order to estimate the contribution of the selected indictors of respondents to assess their sustainability in agriculture, correlation coefficient (r) and multiple regression analysis (B) were used. The major findings of the study are summarized below:

5.1 Major Findings of the Study

5.1.1 Selected characteristics of the respondents

Land productivity

Land productivity scores of the respondents in the study area ranged from 400 to 640 with an average of 504.75 where the highest number (50.8%) of respondents lie in the medium category compared to 20% in low productivity and 28% in high productivity.

Income generating activities

Income generating activity scores of the respondents ranged from 2 to 7 with an average of 4.36 where maximum proportion of the respondents had medium (62%)

income generating activities where only 16.7% had higher and 20.8% had low income generating activities.

Access to financial services

Access to financial services scores of the respondents ranged from 3 to 7 with an average of 5.25 where the highest proportion (57.5%) of the respondents belongs to medium level of access to financial services category while 27.5% respondents had low access and 15% had high access.

Human capital

Human capital scores of the respondents ranged from 41 to 53 with an average of 48.11 where the highest proportion of the respondents had medium level of knowledge, skill and capacity while only a few had low and high human capital with 11.6% and 13.4% respectively.

Adequacy of extension services

Adequacy of extension services scores of the respondents ranged from 2 to 6 with an average of 3.57 where majority of the respondents (62%) in the study area had medium access to extension services where 16.7% of the respondents had low access and 20.8% had high adequacy of extension services.

Access to information related on climate and cropping practices

Access to information related on climate and cropping practices scores of the respondents ranged from 8 to 14 with an average of 10.66 where, a plenty of people (57.5%) had medium access to climate information while 26.7% had low access and only 15.8% of the respondents had frequent access to climate information.

Use of integrated pest and disease management

Use of integrated pest and disease management scores of the respondents ranged from 9 to 16 with an average of 12.60 where majority of the respondents in the study area belongs to the medium category (69.1%) while only 14.2% of the respondents used integrated pest and disease management and 16.7% used IPDM.

Crop diversification

Crop diversification scores of the respondents ranged from 0.40 to 0.68 with an average of 0.58 where the highest proportion of the respondents (70.1%) belongs to the medium category compared to 15.8% low and 14.1% high category. Low and high categories had almost the same proportion of the respondents.

Use of climate smart agricultural technology and practices

Scores of the respondents on use of climate smart agricultural technology and practices ranged from 17 to 30 with an average of 24.73 where maximum proportion of the respondents (58.2%) use a medium level climate smart agricultural technologies and practices where only a small number of respondents belongs to the high category with 13.4% and 28.4% have fallen under low category. This picture reveals that medium category had the highest and high category had lowest proportion of respondents.

5.1.2 Coastal sustainability index

The index was measured by calculating scores of the nine selected variables following some formulae. The score of the developed index ranged from 30.33 to 69.95 with mean 49.25 where 40% respondents belongs to the moderately sustainable category which is the highest compared to 32% reasonably sustainable and 18% in high sustainable category. The figure indicates that a good deal of coastal people are moderate to reasonably sustainable in agriculture where only 9% farmers are in not sustainable category.

5.1.3 Relationships among the coastal agricultural sustainability index and its dimensions:

i) There was a highly significant relationship between social dimension and sustainability, environmental dimension and sustainability, economic dimension and environmental dimension and social dimension and environmental dimension of coastal agriculture in Bangladesh.

ii) There was a significant relationship between economic dimension and sustainability as well as social dimension of sustainability of coastal agriculture in Bangladesh.

5.1.4 Relationships among the selected indicators, dimensions and coastal agricultural sustainability index.

i) There was a highly significant positive relationship among 9 indicators of sustainability and their dimensions.

ii) There was a highly significant positive relationship between the developed index of coastal agricultural sustainability with most of the dimensions.

5.1.5 Contribution of Factors Influencing sustainability of coastal agriculture in Bangladesh

Out of 9 variables only 5 variables viz. land productivity, income generating activities, adequacy of extension services, access to information on climate and farming practices, and use of climate-smart agricultural technologies were statistically significant indicating that these variables had significant contribution to the variation of the coastal agricultural sustainability index. Where land productivity, adequacy of extension services and access to climate information are the most important indicators of sustainability. From these indicators 56.4 percent (R^2 = 0.564) of the variation in the respondents in assessment of sustainability of coastal agriculture in Bangladesh was attributed to their indicators.

5.2 CONCLUSIONS

The findings and relevant facts revealed during the course of the research work prompted the researcher to draw following conclusions:

i. Among the respondents most of the respondents (64.17 percent) were found to be in the effective sustainability category in agriculture.
ii. From developing procedure of SCI, the average score of SCI were 49.2 percent. Thus it may be concluded that around 50 percent of respondents have effective agricultural sustainability.
iii. In the result of dimension level of sustainability, highest result obtained from social dimension which means that social factors contribute the highest for coastal agricultural sustainability.
iv. Land productivity of the respondents showed the important contributing factor to assessment of sustainability by the respondents. This means that high access to

market among the respondents might have influenced to assess the coastal agricultural sustainability.

v. Income generating activities of the respondents showed the important contributing factor to the assessment of sustainability by the respondents. This means that income generating activities might have influenced in assessment of sustainability of the coastal farmers. Conclusion could be drawn that the respondents having more income generating activities could find more scope for sustainable coastal agriculture.

vi. Adequacy of extension services of the respondents showed the important contributing factor to assess agricultural sustainability by the respondents. This means that adequacy of extension services might have influenced in agricultural sustainability of the coastal farmers. So, it may be concluded that the respondents having more access to extension services could be more active for increasing agricultural sustainability.

vii. Regression analysis showed that access to information on climate and cropping pattern was a contributing factor to coastal agricultural sustainability by the respondents. Therefore, it may be concluded that access to information on climate and cropping pattern encouraged respondents to attain sustainability in agriculture.

viii. Regression analysis revealed that integrated pest and disease management was a contributing factor to assess agricultural sustainability by the coastal farmers.

ix. Regression analysis revealed that the use of climate smart agricultural technologies and practices of the respondents was a contributing factor to coastal agricultural sustainability. Therefore, it may be concluded that the use climate smart agricultural technologies and practices by the respondents had influenced the agricultural sustainability.

x. The key problem of coastal agriculture was high price of farm inputs.

5.3 RECOMMENDATIONS

On the basis of findings of the study, some recommendations were kept forward. Recommendations have been divided into two sub sections as: recommendations for policy implication and recommendation for further studies.

5.3.1 Recommendations for policy implication

- Land productivity is an important consideration that ensures food security and it also has an impact on income and livelihood status of the farmers. But in the present study majority of the farmers had low to medium land productivity. Therefore, it is recommended that effective steps (e.g. provision of HYV crops, boosting irrigation, rational use of fertilizer etc.) should be taken by the extension service providers to increase land productivity of the farmers.

- Adequacy of extension services had significant relationship with agricultural sustainability of the farmers. That means higher the adequacy of extension services for the farmers, higher the increase in the level of agricultural sustainability. Majority of the farmers had medium adequacy of extension services. Hence, priority should be given by DAE and other concerned authorities for enhancing the access to extension services of the farmers.

- Access to information related on climate and cropping practices of the farmers had positive significant relationship with their agricultural sustainability. So, it is strictly recommended that, the relevant organizations such as DAE, NGOs and other public and private organizations should take necessary actions to provide information on climate and cropping practices on continuous basis.

- Use of integrated pest and disease management was important contributing factors to agricultural sustainability. Therefore, it is recommended that the concern authorities should work with the respondents and prioritize integrated pest and disease management which influences agricultural sustainability of the respondents.
- Use of climate smart agricultural technology and practices had significant positive relationship with agricultural sustainability. Therefore, the information about new technologies and farming practices needs to be disseminated on a wider scale, for instance through farmer training programmes.

5.3.2 Recommendations for further research

A small piece of study cannot provide all the information for proper understanding and determination of coastal agricultural sustainability. On the basis of the scope and limitations of the present study and observations made by the researcher, the following recommendations were made for further study:

- This study was conducted in some coastal areas of Bangladesh like Gournadi, Dumki and Nesarabad under Barisal, Patuakhali and Pirojpur district respectively. Findings of the study need verification by similar research in other coastal areas of Bangladesh.

- This study investigated the effects of nine personal and socio-economic characteristics of the farmers on their sustainability of agriculture. Therefore, it is recommended that further study should be conducted involving other related characteristics of the farmers.

- The study is conducted on sustainability of agriculture in six selected villages in Gournadi, Dumki and Nesarabad under Barisal, Patuakhali and Pirojpur district respectively. The result of the study showed that majority of the farmers had medium agricultural sustainability. To arrive at generalizations as to the agricultural sustainability in the whole country and to draw up policy measures for the whole nation, similar research efforts were needed at other locations.

- Sustainability of coastal agriculture may be determined by using other ways and methods which may be used in conducting further research.

- In the study only nine indicators and some major crops were taken into consideration to determine agricultural sustainability but by taking other indicators and crops grown by the farmers, similar research efforts may be done at other locations.

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APPENDIX – A

DEPARTMENT OF

AGRICULTURAL EXTENSION AND INFORMATION SYSTEM

SHER-E- BANGLA AGRICULTURAL UNIVERSITY

SHER-E- BANGLA NAGAR, DHAKA-1207

AN INTERVIEW SCHEDULE FOR A RESEARCH STUDY ENTITLED

Sustainability of Coastal Agriculture in Bangladesh

Serial No:

Respondent Name: ……..

Village: …………… Union:

Upazila: …………. District:

Please answer the following questions:

1. Land productivity

Yield of modern (rice) varieties (Mon/20 decimal) [ ]

Yield of local (rice) varieties (Mon/20 decimal) [ ]

2. Income Generating Activities

Which of the following types of income generating activities do you have?			
Farming activities		**Non-farming activities**	
Agronomic crop cultivation		Small business	
Horticultural crop cultivation		Seasonal business	
Livestock production		Private job	
Dairy farming		Govt. job	
Poultry raising		Casual labour	
Fish cultivation		Travel(driver, rickshaw puller)	
Nursery		Hotel business	
Shop keeping		Others	

3. Access to Financial Services

Have you taken any financial support during the last 5 years?		Yes	No
If yes, please specify from the list of financial sources			
Financial sources	No access	Intermittent access	Sustained access
Family			
Friends/ Neighbours			
Bank			
Cooperative			
NGO			
Money lenders			
Remittance			
Others			

4. Human capital

Please answer the following questions:

Statement	Definitely	Probably	Probably not	Not sure	Definitely not
Knowledge					
Salinity affects the yield of crops					
Embankment is helpful for farming system					
Sea level rise is a threat for coastal farmer					
Mixed cropping enhances soil nutrient availability					
Skill					
Flood control is important for crop production					
Water harvesting is a good technique of avoiding salinity					
Fish cum rice production is a good source of income					
Safe pesticide application is inevitable					
Capacity					
Education is unique for sustainable farming system					
Training helps to adopt environmentally friendly farming practices					
Organizational participation assists for getting updated information					
Financial capacity is urgent for adopting innovation					

5. Adequacy of Extension Services

Please mention the extent of extension contact in the last year

Query	Extent of extension contact in the past year			
	No visit	Once	2 to 3 times	4 times and above
Extension officers(Agriculture) visit to farmers				
Extension officers(Fisheries) visit to farmers				
Extension officers(livestock) visit to farmers				
Farmers visit to extension officers				

6. Access to information on climate and cropping practices

Climate Change								
* Are you aware of climate change?	Yes	No						
If yes, what changes have you noticed?								
Increased rainfall	Decreased rainfall	Drought	Increased rainfall variability	Increased temperature	Flooding	Late onset of rainy season	Shorter rainy season	Other specify
* Over the last ten years, have you observed any changes relating to the weather?	Yes	No						
If yes, how did these impact your farm system?								
Crop failure	Less farm income	Migration/ off farm work	Higher expenses on agricultural inputs	Reduced fodder yields	Outbreak of pests	other (Please specify)		
Farming Practices								
* Do you have access to information on cropping/livestock practices?	Yes	No						
If yes, how do you get this information? (Please specify form the list)								
Radio								
Newspaper								
Television								
Extension agent								
APFS/FFS								
Other farmers								
Internet resources								

7. Integrated pest and disease management

What measures do you follow to control pest and diseases?							
Pest				**Disease**			
Non-chemical		Chemical		Non-chemical		Chemical	
Yes	No	Yes	No	Yes	No	Yes	No

If non-chemical, then mention the extent of significance, knowledge and usefulness of nonchemical measures in managing pests and diseases.

	Significant(S)			Knowledgeable(K)			Useful(U)		
	Not S	S	Very S	Not K	K	Very K	Not U	U	Very U
Pest									
Disease									

8. Crop Diversification

Please mention total cropped area and the name of crops you grown in the last 5 years

Name of Crops	**Area of cultivation (average of 5 years)**
Rice	
Jute	
Wheat	
Pulse	
Oil seed	
Vegetables	
Maize	
Total cropped area:	

9. Use of Climate-Smart Agricultural Technologies and Practices

Do you use any climate-smart agricultural technology or practice?	Yes	No
If yes, please specify from the list		

Name of the Technologies and Practices	Adequately	Moderately	No opinion	Rarely	Never
Alternate wet and dry rice production system					
Salt tolerant rice varieties					
Leaf colour chart					
Floating gardening					
Legume crop/pulse crop					
Changing cropping pattern					
IPM(non-chemical control)					
Farm yard manure					
Agroforestry					

Thank you for your information. Signature of the Interviewer

APPENDIX B

Dependent Variable Value for Regression (SCA Index X 100)			
39.33761	30.33476	47.74217	57.32906
34.11681	49.70085	49.16667	49.7151
36.0755	37.02279	48.96011	59.57977
46.26068	52.5641	44.52991	46.06838
47.91311	49.15954	48.26211	56.47436
50.86182	59.22365	55.45584	31.30342
54.28775	53.46154	66.19658	47.70655
48.28348	43.8604	35.27066	42.75641
43.0698	65.42735	44.23077	41.08262
53.83903	50.19943	51.75214	61.31054
49.52991	36.16097	35.41311	52.00142
39.92165	50.01994	38.97436	59.48006
39.43732	52.20798	31.91595	57.82051
64.89316	61.81624	42.36467	54.92165
43.37607	51.12536	38.58974	42.0584
36.6453	51.13248	62.54274	55.36325
48.87892	63.37607	33.62536	46.45299
57.64957	53.05556	59.60826	69.95014
52.26496	63.78205	58.65385	53.40456
63.27635	37.30769	37.37892	46.03276
68.25499	47.30057	51.70228	45.92593
42.04416	57.81339	57.54274	52.74929
54.60114	41.06125	43.04843	57.89174
46.21083	68.0057	51.73077	44.92165
53.02707	47.02707	58.36182	52.49288
44.72222	34.5584	45.7906	54.97151
37.91311	63.53276	65.03561	40.99715
45.39886	62.45014	36.78775	43.56125
39.12393	45.87607	34.33048	56.62393
39.35185	47.31481	40.02137	67.74929

APPENDIX C

CORRELATION AMONG THE SCA INDEX, DIMENSIONS AND THEIR INDICATOR'S

CORRELATION MATRIX

	X1	X2	X3	X4	X5	X6	X7	X8	X9	X10	X11	X12	X13
X1	1												
X2	.088	1											
X3	-.006	.144	1										
X4	-.013	-.061	.060	1									
X5	.237(**)	.401(**)	.242(**)	.090	1								
X6	.304(**)	.305(**)	.023	.019	.553(**)	1							
X7	.296(**)	.180(*)	.087	.105	.355(**)	.376(**)	1						
X8	-.052	-.025	-.145	-.056	-.061	-.110	-.111	1					
X9	.247(**)	.176	.085	.084	.228(*)	.364(**)	.269(**)	-.136	1				
X10	.726(**)	.611(**)	.484(**)	-.014	.461(**)	.367(**)	.328(**)	-.108	.291(**)	1			
X11	.264(**)	.327(**)	.158(*)	.478(**)	.815(**)	.782(**)	.409	-.109	.331(**)	.408(**)	1		
X12	.306(**)	.202(**)	.037	.089	.333(**)	.394(**)	.775(**)	.313(**)	.633(**)	.325(**)	.400(**)	1	
X13	.552(**)	.489(**)	.287(**)	.254(**)	.710(**)	.683(**)	.660(**)	.041	.547(**)	.738(**)	.803(**)	.752(**)	1