

Research Papers

2022

Centre for Strategic and Peace Studies (CSPS)
Dhaka, Bangladesh
Compiled: 2024

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**The Role of Zakat in the Provision of Social Protection during COVID-19
and beyond: A South Asian Context**

By

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Year: 2022

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Abstract

This paper discusses the role of Zakat Funds in the provision of social protection in the South Asian region. The purpose of this paper is to assess different modalities of Zakat in South Asia. For this case study, the south Asian countries have been chosen for the study. Four of them, namely, Afghanistan, Bangladesh, Maldives, and Pakistan are Muslim-majority countries. The other four countries, namely, Bhutan, India, Nepal and Sri Lanka where Muslims are minority. Findings are based on a desk review of academic, peer-reviewed literature as well as reports published by international organizations and information provided online by governments and national Zakat Funds. The extent to which Zakat can be used to finance social protection measures varies not only in the way it is collected and administered, but also with the country's geographic and political conditions. In Pakistan, Zakat was mandatory until 1999 and reached proportionally more households than in other countries. While the Quran establishes the eight categories for those who should receive Zakat, the selection in all countries is at the discretion of the Funds' administrators. Among the countries under the case study, Maldives has emerged as the role model in recent years in terms of institutionalization of zakat through state mechanism. The topic of Zakat is one that has received increased attention by researchers interested in Muslim values, social policy and public finance. However, little research has been produced on the intersections of these three topics.

Keywords South Asia, Zakat, Social protection

1. Introduction

Zakat is one of the five pillars of Islam and can be understood as a form of religious duty, purifying one's wealth and, at the same time, functioning as a means to redistribute wealth to those who are in need. In Muslim-majority countries, Zakat has a long tradition in providing income, consumption goods and other basic services such as health and education to the poor and marginalized (Bilo & Machado, 2020). A growing body of research has investigated the role of Zakat in the provision of social protection – understood here as income and consumption transfers with the aim to protect the vulnerable against risks – and its importance as a poverty-reduction mechanism (Ali, 2014; Hassan, 2010; Hassanain and Saaid, 2016; Ibrahim and Ghazali, 2014). Although much of the criticism around Zakat institutions evolves around missing coordination, efficiency and transparency (Johari et al., 2015), Zakat has several advantages when it comes to assisting the poor. In countries where state-provided social protection is limited due to ongoing conflicts, for example, Zakat can play a crucial role in providing support to those in need.

This paper discusses the role of Zakat Funds in the provision of social protection in the South Asian region. The purpose is to assess different modalities of Zakat in four countries where it is regulated in some form by the state. We provide an overview of zakat as source of social protection, legal background and institutional arrangements of zakat, Zakat financing and the extent to which they reach particularly vulnerable groups. With this paper, we thus contribute to an assessment of the advantages and challenges of Zakat as a social protection mechanism and an instrument to reduce poverty and empower those in need.

The paper has been structured as followed. Section 2 has two parts. First part provides an overview of South Asian economy and society. Second part reviews zakat's role as social protection mechanism. Section 3 discusses the methodology employed in this study while Section 4 comprehends the analysis of Zakat Funds in South Asia, with the aim to present their main characteristics and role within the countries' social protection systems. Section 5 is a discussion on some of the common challenges based on the cases analyzed. Section 6 summarizes concluding remarks.

2. Literature Review

This section can be divided into two parts. First part provides a brief on the South Asian Economy and Society. The second part reviews extensive literature on social protection and zakat separately and then attempts to synthesize and integrate the two concepts in the quest for establishing a social protection framework in which zakat has a great to play in Muslim countries as well as the countries where Muslims are minority.

2.1. South Asia: Economy and Society

South Asia comprises Afghanistan, Bangladesh, Bhutan, India, Maldives, Nepal, Pakistan, and Sri Lanka and is home to almost 1.9 billion people 8.5% in 2019 are very poor, having less than US\$2.15 (in purchasing power parity terms) a day to consume (World Bank, 2023).

India and Pakistan are the largest countries in terms of both size and population. The estimated population of India was 1407.56 million in 2021 with average annual growth rate of 1.17% during 2010-2021. The Muslim population constituted 14.6% of the total population, or 205.5 million, the second largest Muslim population in the world behind Indonesia. The estimated population of Pakistan was 231.40 million in 2021, with Muslim population at 96.4% or 223.07 million, the second highest in the world. Pakistan's average annual growth rate was 1.64% during 2010- 2021. Bangladesh is the third largest country in terms of Muslim population in South Asia at 153.1 million (90.4%), followed by Afghanistan at 40.01 million (99.8%). The population growth of Bangladesh and Afghanistan has

remained 1.20% and 3.18% per annum respectively during 2010-2021. The Muslim population of Sri Lanka and Nepal were found to be 1.9 million or 8.5 % and 1.26 million or 4.2 % of the total population in 2021. The population growth of Sri Lanka and Nepal has remained 0.81% and 0.88% per annum respectively during 2010-2021.

The estimated Muslim population in Maldives and Bhutan were 0.51 million (98.4%) and 0.00078 million (1%) respectively. The average annual population growth rate of Maldives and Bhutan has remained 3.34% and 0.9 % per annum respectively during 2010-2021.

Table 2.1: Total Population, Density of Population and Percentage of Muslim Population

Country Name	Total Population (million)	Percentage of Muslim population (2010) ¹ *	Estimated Muslim Population in Millions
Afghanistan	40.10	99.8	40.01
Bangladesh	169.35	90.4	153.1
Bhutan	0.78	1	0.00078
India	1407.56	14.6	205.5
Maldives	0.52	98.4	0.51
Nepal	30.03	4.2	1.26
Pakistan	231.40	96.4	223.07
Sri Lanka	22.15	8.5	1.9

Source: World Development Indicators (2021), World Bank

2.1.1. Trends in Economic Aggregates

This section focuses on broad socio-economic indicators for the region, such as economic growth, structure of the economies, employment, inflation, and poverty levels. The eight countries under focus are diverse in their natural resources, population, geographic area and levels of economic development. Maldives and Bhutan are very small compared to India and Pakistan. According to the World Bank classification of countries, only Maldives belongs to the category of ‘upper-middle’-income countries, the rest are all low-income countries and Afghanistan is low-income country as defined by the World Bank.

All the economies under study made economic progress over the last decade. The GDP of Bangladesh more than tripled, GDP of Nepal more than doubled during 2010-and 2020 (Table 2.2).

¹ Accessed from <http://www.guardian.co.uk/news/datablog/2011/jan/28/muslim-population-country-projection-2030#data>

Table 2.2: GDP in billion USD

Country Name	2010	2015	2020	2021
Afghanistan	15.63	20.00	20.14	14.79
Bangladesh	115.28	195.08	373.90	416.26
Bhutan	1.55	2.00	2.33	2.54
India	1675.62	2103.59	2667.69	3176.30
Maldives	2.59	4.11	3.75	5.41
Nepal	16.00	24.36	33.43	36.29
Pakistan	177.17	270.56	300.43	348.26
Sri Lanka	58.64	85.14	85.35	88.93

Source: World Development Indicators (2023), World Bank

In the similar fashion, GDP per capita of all countries has increased over the past decade. From the Table 2.3, we observe that overall, the GDP per capita quadrupled in South Asia between 2010-2020. In the same period, Nepal's GDP per capita increased more than five times, Bhutan, India and Sri Lanka more than four times, Maldives more than three times, Afghanistan and Bangladesh almost three times. In terms of GDP per capita, Pakistan ranks at the bottom in South Asia with a growth of 2.5 times between 2010 and 2020.

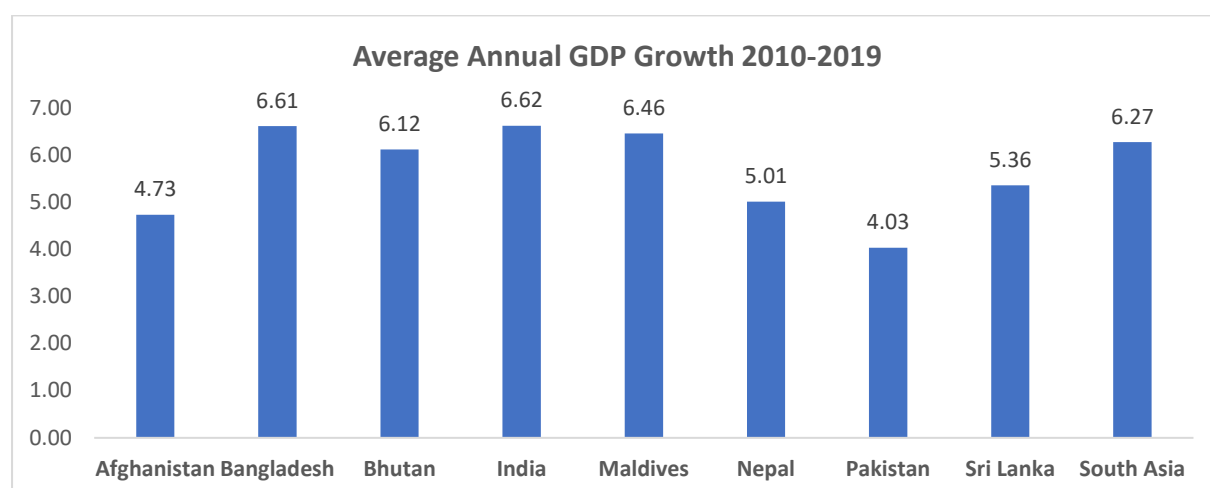
Table 2.3: GDP per capita (current US\$)

Country Name	2000	2010	2020	2021	2010-2020
Afghanistan	184	555	517	369	2.8
Bangladesh	413	777	2233	2458	2.8
Bhutan	723	2194	3010	3266	4.2
India	442	1351	1910	2257	4.3
Maldives	2210	7158	7282	10366	3.3
Nepal	224	589	1139	1208	5.1
Pakistan	531	911	1322	1505	2.5
Sri Lanka	870	2894	3894	4014	4.5
South Asia	448	1242	1852	2150	4.1

Source: World Development Indicators (2023), World Bank

During 2010-2019, four (4) South Asian economies namely Bangladesh, Bhutan, India and Maldives grew at an average annual rate of 6% plus. Sri Lanka and Nepal registered an average annual growth rate of 5.36 % and 5.01% respectively. In terms of GDP growth, Afghanistan and Pakistan recorded at the bottom in South Asia with an average annual rate of 4.73% and 4.03% respectively between 2010 and 2019.

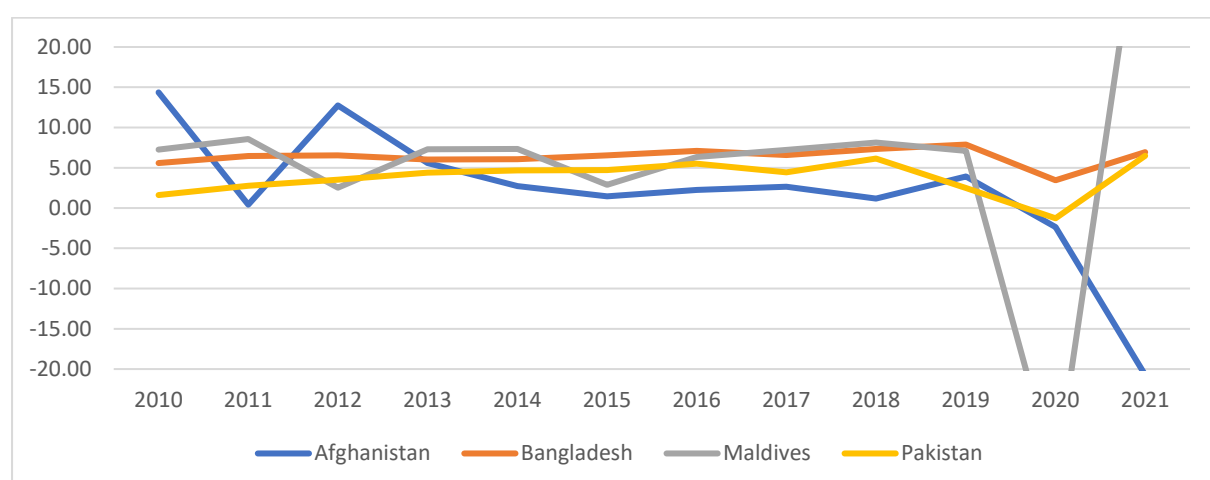
Figure 2.1: Average Annual GDP Growth 2010-2021



Source: World Development Indicators (2023), World Bank

Afghanistan, which was growing at more than 9% annually during 2010-2012, slowed down and recorded an average growth rate of 2.36 % during 2014-19. On the other hand, Bangladesh consistently grew at an average growth rate of 6.61 % during 2010-2019. Though Maldives grew at an average growth rate of 6.46 % during 2010-2019, slowed down and recorded a growth rate of 2.52% in 2012 and 2.88% in 2015. Pakistan grew at an average growth rate of 4.03 % during 2010-2019, highest growth rate was 6.15 % in 2018 and lowest growth was 1.61% in 2010 (Figure 2.2a).

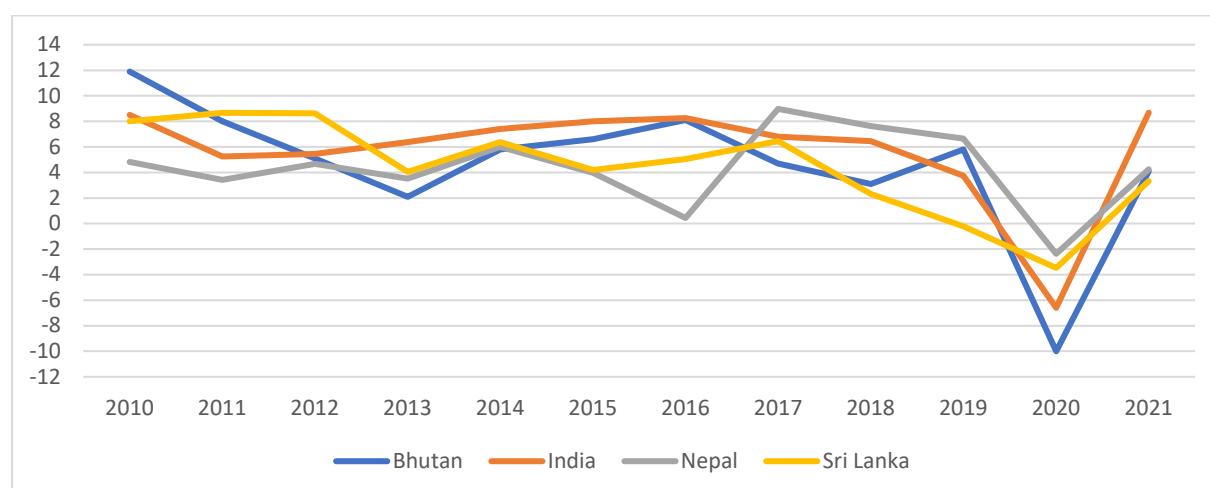
Figure 2.2a: GDP Growth Rate 2010-2021 Afghanistan, Bangladesh, Maldives, Pakistan



Source: World Development Indicators (2023), World Bank

Bhutan started with a growth rate of 11.9% in 2010 and then slowed down to 2.10% in 2013. It grew again and reached 8.10% in 2016. Then slowed down at an average growth rate of 4.53 during 2017-2019. India grew at an average rate of 7.03% during 2010-2016, while the growth slowed down at an average rate of 5.66% between 2017-2019. Though Nepal grew at an average rate of 5.01% during 2010-2019, it registered three phases of growth. In the first phase, it grew at an average rate of 4.4% during 2010-2015 before reaching the lowest growth of 0.43% in 2016 in phase 2. Then, in the last phase, it grew at an average rate of 7.75% during 2017-2019. Sri Lanka grew at an average rate of 6.43% during 2010-2017, it registered a growth rate of 2.31 in 2018 from 6.46 in 2017 and only South Asian country to register a negative growth of (-) 0.22 in 2019 in a pre-Covid-19 world (Figure 2.2b).

Figure 2.2b: GDP Growth Rate 2010-2021 Bhutan, India, Nepal, Sri Lanka



Source: World Development Indicators (2023), World Bank

During the covid-19 pandemic that hit the global economy. Every South Asian country except Bangladesh registered negative growth. While South Asia recorded a negative growth of (-) 5.23% in 2020, Maldives was severely affected with a negative growth of (-)33.49%, followed by Bhutan with -10%. On the other hand, we see South Asian countries turning around in 2021 expect Afghanistan. Maldives registered a staggering 41.75% growth while Afghanistan registered a negative growth of (-) 20% because of political tension (Table 2.4).

Table 2.4: GDP Growth (%) of South Asia: Before and During the Covid-19 Pandemic

Country Name	2020	2021
Afghanistan	-2.35	-20.74
Bangladesh	3.45	6.94
Bhutan	-10	4.1
India	-6.60	8.68
Maldives	-33.49	41.75
Nepal	-2.37	4.25
Pakistan	-1.27	6.49
Sri Lanka	-3.47	3.33
South Asia	-5.23	7.96

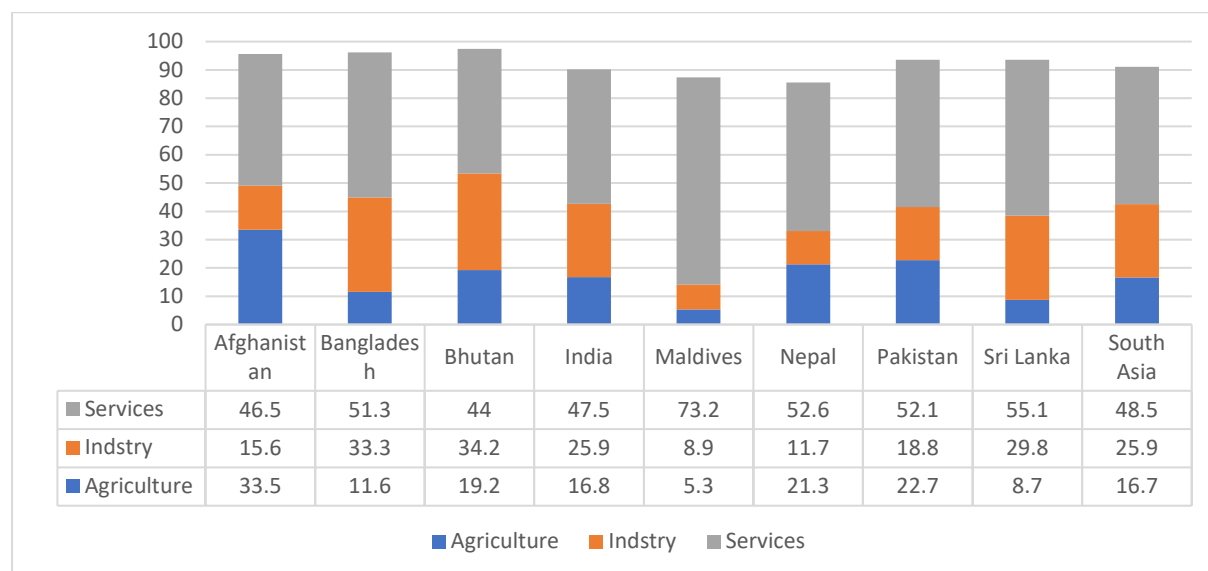
Source: World Development Indicators (2023), World Bank

2.1.2. Structure of Economies

The composition of GDP varies with the average income level of the countries. The contribution of the agriculture sector is low in the countries with higher per capita income compared to the countries with low per capita income. Similarly, the relative contribution of services and industrial sectors is high in high-income countries compared to the low-income countries. The relative contribution of the agriculture sector to Afghanistan's GDP was the highest (33.5%) in 2021, followed by Pakistan (22.7%), Nepal (21.3%) and Bhutan (19.2%). The Indian figure on agriculture sector to GDP is similar to South Asian average while contribution of the agriculture sector to GDP is lower than the South Asian average in three countries. The relative share of the agriculture sector of the GDP of Bangladesh, Sri Lanka, and Maldives was 11.6%, 8.7% and 5.3% in 2021.

The value addition of the industrial sector to the GDP of Bhutan was found to be the highest (34.2%), followed by Bangladesh (33.3%), Sri Lanka (29.8%), and India (25.9%) in 2021. The relative contribution of the industrial sector to the GDP of Maldives was the lowest (8.9%), followed by Nepal (11.7%), Afghanistan (15.6%) and Pakistan (18.8%) among the countries under study in 2021. However, the relative contribution of the services sector to the GDP of Maldives was the highest (73.2%) among the countries under study in 2021 (see Figure 2.3)

Figure: 2.3: Agriculture, Industry, and Services in the 8 SA countries for 2021



Source: World Development Indicators (2023), World Bank

2.1.3. Unemployment

South Asia unemployment rate for 2021 was 7.30%, a 1.96% decline from 2020. In Bhutan, the unemployment rate as a percentage of total labor force has been low (on average 3.12% per annum) during 2010-2021 compared to the other countries under study. Pakistan, Bangladesh and Sri Lanka experienced an unemployment rate of 3.43%, 4.35%, and 4.45% per annum respectively during the same period. Nepal and Afghanistan recorded high unemployment rates during the last decade, which was on average 10.9% and 9.46% per annum respectively. Many researchers have empirically studied the factors affecting the level of unemployment in South Asia. Shabbir, Kousar, & Alam (2021) show a negative and significant relationship among governance, internet users, mobile cellular subscriptions, fixed broadband subscriptions and human capital with an unemployment rate of South Asian economies. On the other hand, financial activity (credit) and population growth have a positive and significant relationship with the unemployment rate.

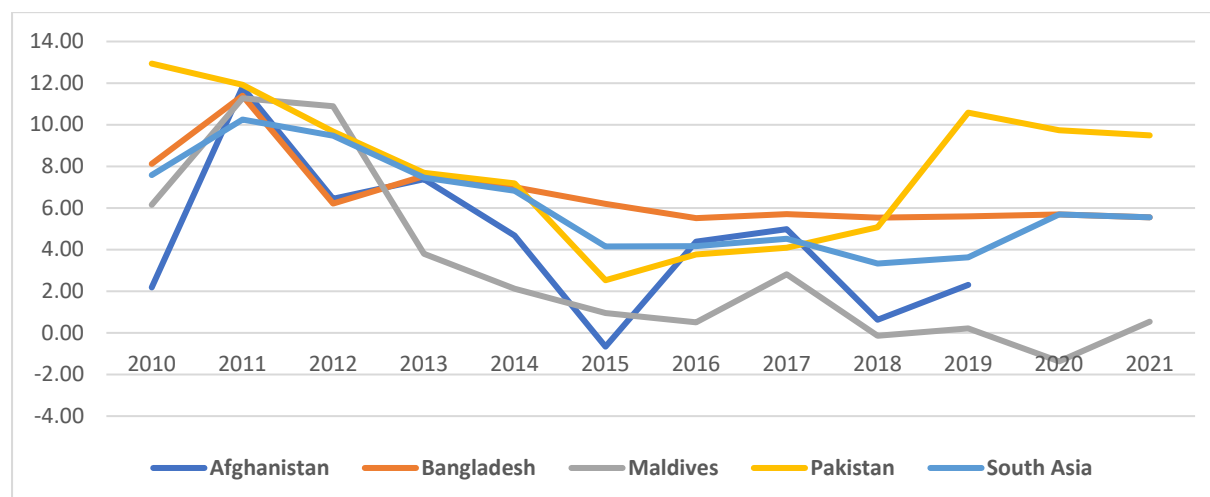
2.1.4. Inflation

In South Asia, the inflation rate has been on average 6.05% per annum during 2010-2021, which can be seen in three phases. First phase is high inflation between 2010 and 2014, on average 8.32% per annum. Within this phase, South Asian inflation crossed double digit in 2011 with 10.25%. The second phase is low inflation between 2015 and 2019. Consumer prices were stable and low in this period as inflation came down to on average 3.96% per annum. Then the third phase is moderate inflation between 2020 and 2021, on average 5.62% per annum.

Maldives and Afghanistan have emerged as the two best performing countries in terms of containing inflation. On average, inflation has been about 3.15% in Maldives and 4.41% per annum during 2010-2021. Though Maldives experienced double digit inflation in 2011 (11.27%) and 2012 (10.88%), the

country has been able to maintain an inflation on average 0.5% between 2015 and 2020. On the other hand, the economy of Pakistan was badly hit by increasing consumer prices over the last decade. On average, inflation has been about 7.89% per annum during 2010-2021 (Figure 2.4a).

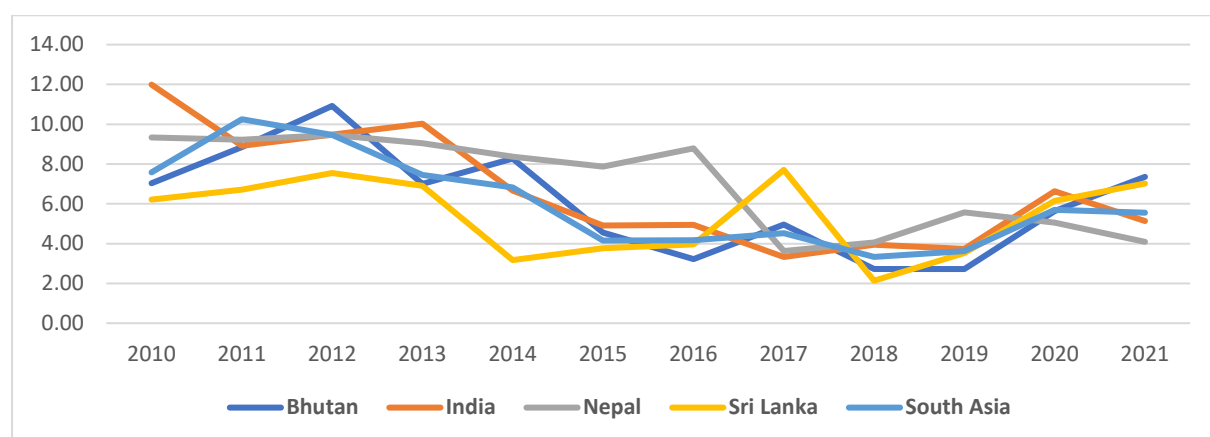
Figure 2.4a: Inflation, average consumer prices, 2010-2021, Afghanistan, Bangladesh, Maldives, Pakistan, and South Asia



Source: World Development Indicators (2023), World Bank

Between 2010 and 2013, India experienced a high inflation on average 10.10% per annum. In comparison to this period, the rest of the period of the last decade, India maintained a moderate inflation on average around 5% between 2014 and 2021 (Figure 2.4b).

Figure 2.4b: Inflation, average consumer prices, 2010-2021, Bhutan, India, Nepal, Sri Lanka, and South Asia



Source: World Development Indicators (2023), World Bank

2.1.5. Income Distribution

Table 2.5 illustrates income distribution in the region estimated using the Gini index. Income distribution in Bangladesh degraded from 27.2% in 1980-1989 to 30.25% in 1990-1999 and 33.3 % in 2000-2009. However, income distribution has slightly improved over the last decade to 32.25% in 2010-2019. The decline in Bhutan's Gini index from 39.5% in the 2000s to 38.1% in 2010s is quite insignificant. The same is true for Pakistan where Gini index marginally declined from 30.15% in 2000s to 29.78% in 2010s. In India and Sri Lanka, income distribution has deteriorated in the last decade. The Gini Index increased slightly from 34.9% in 2000s to 35.23% in 2010s in India and from 38.67% in

2000s to 39% in 2010s in Sri Lanka. On the other hand, Maldives and Nepal have shown remarkable progress in improving income distribution in the last decades. The Gini index fell from 39.85% in the 2000s to 30.3% in the 2010s in Maldives and from 43.8% in 2000s to 32.8% in 2010s in Nepal.

Table 2.5: Income Distribution - GINI index (%)

Country Name	1980-1989	1990-1999	2000-2009	2010-2019
Bangladesh	27.2	30.25	33.3	32.25
Bhutan			39.5	38.1
India	32.5	31.7	34.9	35.23
Sri Lanka	32.5	33.9	38.67	39
Maldives			39.85	30.3
Nepal		35.2	43.8	32.8
Pakistan	33.3	31.67	30.15	29.78

Source: World Development Indicators (2023), World Bank

2.1.6. Incidence of Poverty

Not least because of its large population size, South Asia has more poor people than any other region in the world (Chowdhury and Mahmud, 2008). However, all the countries experienced reduction in the incidence of poverty over the last decade. Latest poverty estimates according to the World Bank's World Development Indicators show that the proportion of population below US\$2.15 (PPP) a day was 13.5% in Bangladesh in 2016, 10% in India in 2019, 8.2% in Nepal in 2008, 4.9% in Pakistan in 2018, 1.3% in Sri Lanka in 2016 and 0.9% in Bhutan in 2017 (World Bank, 2023). Col.2 shows the share of the population living on less than \$3.65 a day in South Asia. We find that 15% in Bangladesh in 2016, 12% in India in 2019, 11% in Nepal in 2010, 9% in Pakistan in 2018, 3% in Sri Lanka in 2016 and 2% in Bhutan in 2017 are living below the poverty line. There are no poor people in Maldives in 2019 under these two poverty categories. Col. 3 presents the proportion of the population below the national poverty line.

Table 2.6: Poverty headcount ratio in South Asia

Country Name	\$2.15	Year	\$3.65	Year	National	Year
	Col.1		Col.2		Col.3	
Afghanistan					54.5	2016
Bangladesh	13.5	2016	15	2016	24.3	2016
Bhutan	0.9	2017	2	2017	8.2	2017
India	10	2019	12	2019	21.9	2011
Maldives	0	2019	0	2019	5.4	2019
Nepal	8.2	2008	11	2010	25.2	2010
Pakistan	4.9	2018	9	2018	21.9	2018
Sri Lanka	1.3	2016	3	2016	4.1	2016
South Asia	8.5	2019	11	2019		

Source: World Development Indicators (2023), World Bank

It is observed that 54.5% people in 2016 are living below the national poverty line in Afghanistan, the highest in South Asia, followed by 25.2% in 2010 in Nepal, 24.3% in 2016 in Bangladesh. The poverty rate is equal at 21.9 % in India in 2011 and in Pakistan in 2018.

Bhutan, Maldives, and Sri Lanka have been quite successful in fighting poverty bringing it to a single digit. (Col.3, Table 2.6). In 2017, 8.2% of the overall population were found to be poor in Bhutan. In 2019, 5.4% of the overall population were found to be poor in Maldives. In 2016, 4.1% of the overall population were found to be poor in Sri Lanka.

2.2. Zakat in the Social Protection Framework

The word zakat came from the Arabic zakkaa, yuzakki, tazkiyatan, zakaatan, which means at-thohuru (to purify), al-barakatu (to bless), an-numuw (to grow), and as-sholahu (completeness). Allah said in the Quran, “Take, [O, Muhammad], from their wealth a charity by which you purify them and cause them increase, and invoke [Allah’s blessings] upon them. Indeed, your invocations are reassurance for them. And Allah is Hearing and Knowing” (Quran At-Taubah, 9: 103). Zakat itself is a mandatory duty, or waajib, for all Muslims, which means that whoever does not participate in it will be consider sinful.

By contrast, shadaqa is not mandatory but voluntary. The equivalent terms in conventional finance are alms and charity, respectively. Another difference between zakat and shadaqa is the donor: Only those who have wealth of more than a certain level (nisab) must donate zakat, whereas everyone, regardless of wealth, could donate a shadaqa. Islam also regulates the amount of zakat that can be donated, but not shadaqa.

Lastly, unlike shadaqa, the recipients of zakat are also regulated in the Quran Surah At-Taubah verse 60. The verse outlines eight groups of zakat recipients, namely: (1) the poor, (2) the needy, (3) the zakat collector, (4) new Muslims, (5) the slaves, (6) those who are in debt, (7) in the cause of Allah, and (8) the traveler.

In many countries, it is a constitutional obligation to provide a minimum standard of living for all. While building a resilient Social Protection (SP) system is necessary for a country to move towards a welfare state, the priorities of selecting SP programs are different. The aging population is one of the concerns in rich countries such as Singapore and Japan, so the SP system in these countries includes various insurance for elderly people. Such as: Long-term Care Insurance in Japan. On the other hand, in the least developed countries (LDCs) and developing countries, poverty alleviation and providing income security for individuals are still the major concerns. Even they cannot allocate enough resources to address these concerns because of a lack of public resources. This paper studies the case of South Asia who belong to this second category of countries.

In this context, it is very pertinent to ask whether Islam can eliminate Poverty? First of all, this question is not correct. If we look back to the golden age of Islamic history, we would see that poverty was completely eradicated in its various stages. There was a time, for example the era of Umar ibn Abd al-Aziz (2 November 680 – 5 February 720), when there were no people in the society to receive zakat. No country in the so-called advanced civilization of the western world (USA) can even today claim this achievement of complete eradication of poverty. Still, mass people ask this question because of the prevalence of acute poverty in most of the Muslim countries and the lack of Islamic discourse on poverty in the society. Therefore, before understanding the role of zakat in the grand scheme of poverty alleviation in Islam, it is worthwhile to revisit the steps and strategies Islam has adopted to eradicate poverty.

One of the influential Islamic scholars of the last 150 years’ history of Islam, Yusuf al-Qaradawi, has shown three ways of Islamic solution of poverty problem in his book, “Poverty Alleviation in Islam”. These are: Self-Responsibility, responsibility of Muslim Ummah, and responsibility of the Islamic state. At individual level, if a person has ability and opportunity for working, he must work to manage his livelihood. The duty of the society and the state is to assist him in terms of training and cheap capital

so that s/he can find an appropriate livelihood. In the second stage, the Muslim Ummah or the society will take responsibility for providing financial security of the poor in the following ways: Spending for the nearest relatives; Preserving the rights of the neighbors; Paying obligatory Zakat; Providing ordained incidental right on wealth such as *Kaffara (fine)*, *Mannot* (promise), helping the vulnerable people and so on; temporary or perpetual voluntary *Sadakah* such as *Waqf* system. In the third stage, the Islamic state will take initiative for the excellence of every destitute who has no guardian or no way to earn, whether he is Muslim or not, if he lives in a territory of Islamic state. There are three sources of such state guardianship. Zakat is main everlasting source of treasury of Islamic state in alleviating poverty. The second source is one fifth of *Ganimath*, *Fai*, *Khiraj*, *Jijiya*, abandoned property etc. The third and extra sources are imposing tax on rich, if amount of zakat and other sources aren't enough to reduce poverty.

Sadeq (1997) contends that any poverty eradication scheme has to be based on an inquiry into the causes of poverty. At a macro level, there are two possible causes of poverty. First is the low level of Gross National Product (GNP) and second, the unequal distribution of income. At a micro level, poverty may be caused by several reasons. A person may be poor because he is unemployed, handicapped and so on or, just because he is born in a poor family and hence is deprived of equal social opportunities.

A poverty alleviation program should keep all these in view for an effective policy formulation and implementation. The poverty alleviation would thus include policies as follows:

1. To increase GNP with a pragmatic and effective economic development plan,
2. To achieve equity in the distribution of income
3. To provide equal opportunities to all in the society for upgrading economic conditions of the disadvantaged people, and
4. To address individual issues of specific situation

Islamic approach to poverty alleviation involves three distinct sets of measures. These are as follows:

- 1) Positive measures: Islam engages different positive measures in alleviating poverty. Such measures are:
 - a) Income growth
 - b) Functional distribution of income
 - c) Equal opportunity
- 2) Preventive measures: In an Islamic economy, preventive measures are taken so that wealth is not concentrated in a specific section of population. Such preventive measures include:
 - a) control over ownership and
 - b) prevention of malpractices
- 3) Corrective measures: Under such measures, Islamic principles establish different modes of wealth transfers so that wealth is not concentrated among the rich:
 - a) Compulsory transfers: *Zakat*
 - b) Recommended transfers: charity
 - c) State responsibility: Enforcement and fulfillment of basic needs

Following figure explains the whole thing at a glance-

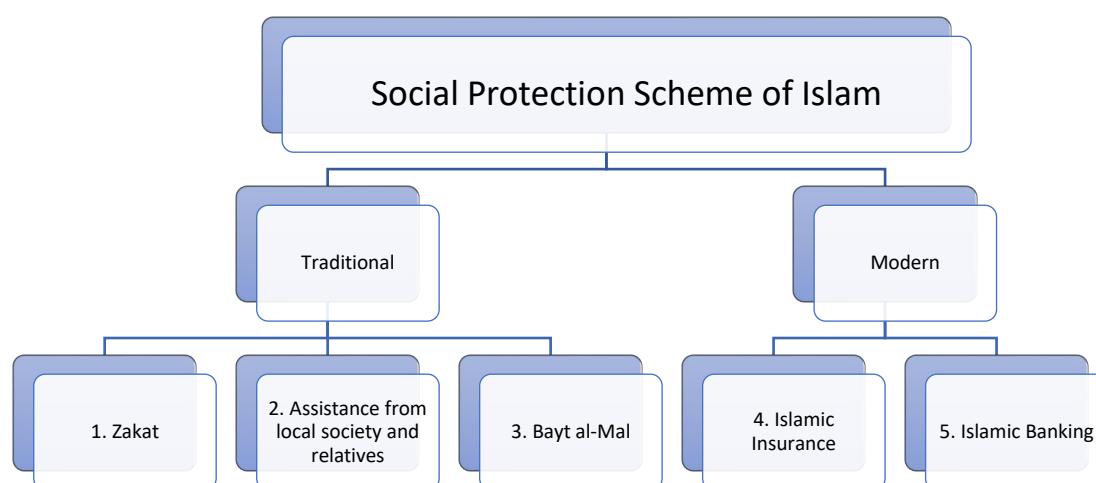
The poverty alleviation strategies and policies are multi-dimensional; one of them is Charity. Again, charity is of several kinds:

- a) Compulsory Charity: *Zakat* and *Fitrah*
- b) Optimal Charity: *Sadaqah*
- c) Perpetual Charity: *Waqf*

So, we see that Islam has a comprehensive package in its scheme of poverty alleviation. In this package, the compulsory and optional charities deal with the poverty problem by adopting a redistributive approach, while waqf can be used to enhance the capabilities of the poor to take part of themselves by providing access to education, health, physical facilities, and so on. Thus, for poverty alleviation, the integration of zakat and waqf is very crucial.

The Islamic approach to social protection in Hannan (2002) involves five instruments, as presented in Figure 2.5:

Figure 2.5: Social Protection Scheme of Islam



Source: Hannan (2002)

First of all, zakat is not like any general tax or duty. It can only be used in specific tasks. It is the main foundation of social and economic protection.

Secondly, assistance from local society and relatives is the informal but critical source of support for any weak and needy person from time immemorial. Islam has encouraged Muslims to practice *Qard al-Hasan* (interest-free loan), enhancing brotherhood and sense of fellow-feeling in society.

Thirdly, if zakat and assistance from local society and relatives are not adequate for social protection, *Bayt al-Mal* emerges to achieve this purpose. *Bayt al-Mal* is the resource of the general people. The provision of social security from both Muslims and non-Muslims can be ensured from *Bayt al-Mal*.

Fourthly, Islamic insurance can emerge as social protection in this modern age in Islamic society and state. Notably, poor people are not covered in the conventional insurance system. If Islamic insurance can be adequately mobilized, it will reduce pressure on Zakat and *Bayt al-Mal*.

Fifthly, Islamic banks can play an essential role in establishing social protection in the present age. Islamic banks can invest in youth and working-class based on *Mudarabah* to grow entrepreneurship. For this, large sums of money are not required. In this way, millions of children can be free from the jaws of unemployment and engage in productive work. Thus, it widely contributes to the enhancement of social protection.

3. Methodology

This study is based on a desk review of academic, peer-reviewed literature and reports published by international organizations and information provided online by governments and national Zakat Funds. This is basically a comparative case study. Comparative case studies involve the analysis and synthesis of the similarities, differences, and patterns across two or more cases that share a common focus or goal

in a way that produces knowledge that is easier to generalize about causal questions – how and why particular programs or policies work or fail to work (Goodrick, 2014). Comparative case studies usually utilize both qualitative and quantitative methods and are particularly useful for understanding how the context influences the success of an intervention and how better to tailor the intervention to the specific context to achieve the intended outcomes (Goodrick, 2014). For this case study, the south Asian countries have been chosen for the study. Four of them, namely, Afghanistan, Bangladesh, Maldives, and Pakistan are Muslim-majority countries. The other four countries, namely, Bhutan, India, Nepal and Sri Lanka where Muslims are minority.

The findings are based on a desk review of academic, peer-reviewed literature as well as reports published by international organizations and information provided online by governments and national Zakat Funds.

4. Case studies

In this section, the cases of Zakat Funds in South Asia, with the aim to present their main characteristics and role within the countries' social protection systems are analyzed as follows.

4.1. Afghanistan

Afghanistan is a South Asian landlocked multiethnic country. The capital of Afghanistan is its largest city, Kabul. A serene city of mosques and gardens during the storied reign of the emperor Bābur (1526–30), founder of the Mughal dynasty, and for centuries an important entrepôt on the Silk Road, Kabul lay in ruins following the long and violent Afghan War. No national census has been conducted in Afghanistan since a partial count in 1979, and years of war and population dislocation have made an accurate ethnic count impossible (<https://www.britannica.com/place/Afghanistan/Plant-and-animal-life#ref21423>)

Virtually all the people of Afghanistan are Muslims, of whom some fourth-fifths are Sunnis of the Ḥanafī branch. The others, particularly the Ḥazāra and Kizilbash, follow either Twelver or Ismā'īlī Shī'ī Islam. Sufism has been historically influential in Afghanistan, though in the 21st century fewer than one-tenth of Afghans belong to a Sufi order. <https://www.britannica.com/place/Afghanistan/Languages>

Zakat collection and distribution systems have existed in Afghanistan for centuries. Katib (2012) mentions proclamations in the late 1800s and early 1900s for the collection of Zakat on sheep, lambs, goats, camel skins and cash from tribes in certain areas, and documents conflicts between Zakat collectors and those meant to pay Zakat. More recently, Zakat collection was conducted by the Taliban (Afghanistan Analysts Network 2020), but procedures differed from one province to the next, and there is no historical record of systematic collection anywhere in the country (Afghanistan Analysts Network 2021).

Presently, Zakat is a private practice in Afghanistan, with Afghans independently paying their Zakat at their own discretion and usually to people within their villages or to relatives. The previous government's Ulema Council, the entity responsible for the interpretation of Islamic jurisprudence, did not issue any fatwas¹ in relation to Zakat. Nonetheless, it is listed in the Social Protection Law (2011) as one of the resources for social protection expenditure. Despite the lack of any clear direction for State-led Zakat collection, some government institutions such as the Ministry of Labor and social Affairs of the former government have expressed a preference for the institutionalization of a Zakat Fund. The different forms of Zakat collection will thus be explored in the next section (Hammad, 2022).

4.2. Bangladesh

Bangladesh officially the People's Republic of Bangladesh, is the eighth-most populous country in the world, with a population exceeding 162 million people. In terms of land mass, Bangladesh ranks 92nd, spanning 148,460 square kilometers, making it one of the most densely-populated countries in the world. Bangladesh shares land borders with India to the west, north, and east, Myanmar to the southeast, and the Bay of Bengal to the south. Bangladesh is predominantly a Muslim nation where 90 percent of the population follow Islam as their religion.

Though the government formed Zakat fund in 1982 which is operated by a board under Islamic Foundation, zakat has not been institutionalized yet in Bangladesh. Hence, collection in the Government zakat Fund is very meager. This displays that the foundation has failed to earn credibility and trust of rich people. The board's Zakat collection has reached from Tk 1.51 million in the FY 1982-83 to Tk 21.98 million in the financial year (FY) 2004-05 and further increased to Tk 51.20 million in the FY 2018-2019. The board has spent Tk 198.15 million between FY1982-1983 and FY 2016-2017 among the 827,255 Zakat beneficiaries. According Mahabub Alam, director of the Zakat Board, (Rahman, 2019), the amount of Zakat could reach Tk 10 billion if the people who have surplus income of more than Tk 35,000 to Tk 40,000 in a year gave their Zakat to the fund. In a recent column in the Financial Express, Asjadul Kibria calculates that Zakat collection in Bangladesh should be at least Tk 600.0 billion in FY 19 (Kibria, 2020).

Experts observed that the size of the state-run Zakat fund is relatively small because of a serious lack of trustworthiness and acceptability of the fund among the mass people. Zakat fund has failed to launch any viable projects that can boost confidence of the people to this fund. The fund collection by the board is so meager though a tax rebate provision is in place for the Zakat payers, and this means the board has failed to attract a large number of rich people to give Zakat. The government is sacrificing a large amount of revenue by offering tax rebate for Zakat givers; but the fund runs dry for a long time though financially able adult Muslims are increasing in number over the years (Muhammad Abdul Majid, a former chairman of the National Board of Revenue (NBR) in Rahman 2019).

The government's higher authority has a lack of focus on Zakat collection. Limited manpower is a major challenge for raising a substantial amount of Zakat. Currently the board has only five officials. To address this challenge, the deputy commissioners (DC) are being involved directly by the board to raise the fund (Shamim Mohammad Afjal, director general (DG) of the Islamic Foundation in Rahman 2019). The board has also lack of publicity and campaign.

In contrast, some voluntary organizations like Centre for Zakat Management (CZM), Anjuman Mofidul Islam, Ahsanullah Mission etc. have shown a success to some extent in mobilizing and distributing Zakat. Center for Zakat Management (CZM) was started in 1993 as a Zakat Forum (ZF). ZF was launched mainly with the active support of Rahimafrouz Bangladesh Ltd. Currently, CZM has the following 8 programs: (1) *Jeebika* – Livelihood & Human Development; (2) *Mudareeb* – Micro Enterprise Development Program; (3) Genius – Scholarship Program for Undergraduate Students; (4) *Ferdousi* – Primary Healthcare Program; (5) *Gulbagicha* – Pre-primary Education & Nutrition Program; (6) *Insaniat* – Emergency Humanitarian Assistance Program; (7) *Dawah* – Advocacy and Awareness Building Program; and (8) *Naipunna Bikash* – Vocational Training for Unemployed Youth. With the prolific initiatives of the CZM, has already been able to raise nearly Tk 300 million as Zakat fund since 2008 through its unique initiative and attractive schemes (Muhammad Abdul Majid, a former chairman of the National Board of Revenue (NBR) in Rahman 2009).

Hossain Zillur Rahman (2014 and 2018) conducting a rapid assessment of the Jeebika Karnaphuli project of CZM claims that the Project provides a new model of financial empowerment that has

introduced a whole new category of program support namely ‘equity capital’ based on the zakat donation. Together with a stronger focus on community, a more supportive repayment culture and a parallel program support package aimed at the social needs of the extreme poor, the *Jeebika Karnaphuli Mohora* Project model merits serious further attention as a new and potentially more transformative model of financial empowerment. The Project has demonstrated that the institutionalization of Zakat can be an effective instrument of poverty alleviation.

Of late, there is a sign of progress towards institutionalization of Zakat. At government level, Access to Information (a2i), the flagship program of Digital Bangladesh, has launched the first Crowdfunding FinTech Platform in Bangladesh titled ‘Ek Desh’ to disburse Zakat and Relief Payments Digitally. BRAC, Bidyanondo Foundation, the Rahimafrooz group, and the Islamic Foundation of Bangladesh, and thousands of volunteers have joined with ‘a2i’ in its drive for collecting large amounts of zakat donations. At Nonprofit Organization (NGO) level, JAAGO Foundation has launched an online platform to collect ‘Zakat for Education’ (Khan, 2020).

It is said that awareness on Zakat’s role in poverty alleviation has been increased in recent years among the politicians, policy makers and academicians. It has been an established fact that Zakat can be a safe and better option to assist millions of poor and vulnerable people. Hence, more NGOs and private organizations should come forward to organize zakat locally and nationally. Finally, the government of Bangladesh should not miss this opportunity of using zakat as a potent frontier in poverty alleviation through institutionalization of zakat (Khan, 2020).

4.3. Bhutan

Bhutan is officially known as the Kingdom of Bhutan. It is a landlocked country in South Asia, situated in the Eastern Himalayas, between China in the north and India in the south. Nepal and Bangladesh are located near Bhutan but do not share a border with it. The country has a population of over 727,145 and territory of 38,394 square kilometers (14,824 sq mi). It is estimated that between two-thirds and three-quarters of the Bhutanese population follow Vajrayana Buddhism, which is also the state religion. About one-quarter to one-third are followers of Hinduism. Other religions including Muslim’s account for less than 1% of the population. The official religion in Bhutan is Vajrayana Buddhism, which is practiced by almost 85% of the population. Bhutan is a Buddhist country by constitution and Buddhism plays a vital role in the country.

According to United Nations Population Division, there are 0.78 million people in Bhutan in 2021. Buddhists are 70.5 percent of the total population, Hinduism 23.9 % and Muslims 6% in 2013, according to The Cline Center for Democracy. In 2010, the Pew Research Center estimated that 0.1% of the population were Muslims and Islam has no recognition there according to Bhutan constitution (PRC, 2010). Bhutan’s Muslim community is so small in size that this researcher has failed to find out any zakat related information from the internet sources using search engine like google scholar. However, some important information that can be interesting for the Muslim travelers to Bhutan. There are currently no halal-certified eateries in Bhutan. However, Le Meridien hotels in Thimphu and Paro offer halal-certified meats. There is no mosque in Bhutan. But there is a small prayer room for Muslims located at Bumthang, Ura Hw. (<https://www.drukasia.com/bhutan/is-there-halal-food-or-mosques-in-bhutan/>)

4.4. India

India, officially the Republic of India is a country in South Asia. It is the second-most populous country, the seventh-largest country by having a land area of 3,287,263 square kilometers. It shares land borders with Pakistan to the west; China, Nepal, and Bhutan to the north; and Bangladesh and Myanmar to the east. Among 1,210,193,422 residents reported in the 2011 census report, the largest number of followers

was Hinduism (79.80% of the population). Muslims are the largest minority community with 14.4 per cent (Census of India, 2011) of India's total population.

Ashiq and Mushtaq (2020) argues that the socio-economic and cultural status of the Muslims varies across the states. For instance, the living conditions of Muslims in Kerala is much better than the Muslims in Uttar Pradesh and West Bengal. As a result of this, in relatively more prosperous chunks of Muslim communities, Zakat circulation is within that specific area only considering the convenience in the localized management of zakat welfare delivery system. On the other side, due to these structural problems of the circuitry of zakat funds, the real and needy people living in different regions are not getting appropriate benefits. The local management of zakat leads to the prosperity of the prosperous region. At the same time, it continues the poor living conditions in the other end. To improve the living conditions of the Muslims across India, a professionally organized zakat system is urgently needed from collection to distribution of zakat funds (Ashiq & Mushtaq, 2020). Previous studies highlight that the Muslim community has the lowest rate of enrollment in higher education in India, accounting for just 4.4% of students. An integrated approach for Zakat management may usher an opportunity of using the Zakat funds for productive purpose like the educational improvement of the community (Ashiq & Mushtaq, 2020).

Association of Muslim Professionals (AMP) based in Maharashtra, Mumbai is a Platform for all Muslim professionals and volunteers to share their knowledge, intellect, experience, and skills for the overall development of not just the Muslim community but also the society at large, and further empowering Muslims in the educational, social, political and economic front of life (AMP website, 2020). AMP has been organizing Zakat disbursement since 2013. In 2013, AMP collected an amount of 2,06,000 Indian rupees from 40-odd donors as Zakat Fund which reached to 89,96,082 Indian rupees in 2019. So far, AMP Zakat Fund has empowered lives of 2193 people by promoting education and self-employment. It has proven that Zakat can be effectively utilized to bring out the Community from the throes of misery. AMP Zakat Fund now aims to undergo transformation to the next level for a pan-India appeal and reaching out to more needy Muslims. This will ensure that the Fund will spread its reach to every city, town and village in India and will touch more lives in the years to come. The Table-4.1 exhibits the breakdown of the distribution of zakat according to the categories of beneficiaries.

There has been no recent study to calculate the potential Zakat collection in India. Association of Muslim Professionals (AMP) estimates that Rs7,500 crores are collected every year in the country and donations could even be Rs40,000 crores. However, Rahmatullah (2005) tried to find an estimate of zakat collection in India. Using government and independent statistics on per capita income and charity, he arrived at the figure of Rs10,000 crores. In an interview with Nair (2016), Rahmatullah stated that the contributions must have tripled since then keeping in view the increase in per capita income and the amount could be Rs30,000-Rs 40,000 crores. Paying attention to the best interest of Muslims, Rahmatullah emphasized on a study to calculate how much money is collected. In an interview with Nair (2016), Siraj Hussain, former Indian Administrative Service officer, said that the figures are inflated. Based on the per capita income of Muslim families in the NSSO (National Sample Survey Office) data, any calculation will show that the estimate of charity is too high. There is no transparency because most transactions are in cash and the collection is poorly organized. The community is so poor that even if the donations are made by cheque the amount will be below the estimates.

Table 4.1: Zakat Fund Disbursement

Sectors	Year 2013		Year 2016		Year 2019	
	Fund	Beneficiaries	Fund	Beneficiaries	Fund	Beneficiaries
Higher Education	1,00,000	10	10,30,000	103	31,87,897	255
Self-Employment	1,00,000	5	12,65,000	50	30,04,500	150
Orphans Scholarship	-	-	5,73,000	120	9,32,298	246
IIT Scholarship	-	-	8,50,000	5	7,50,000	5
Specific Donations	-	-	1,48,000	6	95,000	3
Delhi Riot Victims (2019)	-	-			10,00,000	100
Total	2,00,000	15	38,66,000	284	89,69,695	759

Source: adapted from Association of Muslim Professionals (AMP) website

https://www.ampindia.org/amp_zakat_fund

In an interview with Nair (2016), Syed Zahid Ahmad, who was associated with All-India Council of Muslim Economic Upliftment, suggested that the government should set up bodies similar to the Wakf boards (a statutory body which administers Muslim religious trusts) to manage the funds. There is mismanagement and donors and the agencies that collect charity do not reveal the true figures because there is a lot of black money.

Zakat is being misused in India. Refereeing to Arif Raza, a zakat collector from Bihar, from whom two miscreants snatched of Rs 45,000, Wajihuddin (2012) stated that Raza is one of the thousands of Zakat collectors camping in Mumbai during the month of Ramadan. His way of collecting zakat and his lack of concern for its safekeeping speaks volumes about the serious lacunae in zakat collection. In an interview with Wajihuddin (2012) senior cleric Maulana Shoet Kot said that zakat collectors work mostly on commission. Armed with the names and addresses of individuals, they swoop down on the city. Those who give zakat have no time to verify the credentials of the collectors. Many of these zakat collectors are professional beggars. Nobody checks whether their madrassas really exist or exist only on paper.

Zakat is playing a great role in helping fellow humans in distress during the Covid-19 pandemic time in India. Pavan (2020) reports that in Hyderabad, Zakat saw new heights of humanity in Ramadan of the year 2020. People did not differentiate between communities and castes. They donated to whoever they knew was suffering. Several young earners formed social media groups and collected what the members offered, mostly online. they distributed to the needy, who approached them. Zakat is of the size of Rs 1000 crore in Hyderabad. The organized zakat system has helped an estimated 40 percent of the community population in Andhra Pradesh and Telangana in the last three decades. Health, education, remarriage of young widows, housing and relief in calamities are among the major initiatives taken up with zakat funds. Hyderabad Zakat Charitable Trust, Safa Baitul Maal and some other important groups served the humanity during lockdown. In this year 2020, Muslims have paid not only zakat to the regular beneficiaries but spent up to 10% amount of their income in lockdown relief.

Another great initiative amid the Covid –19 crisis came from Association of Muslim Professionals (AMP), which launched “IndiaZakat.com”, a unique Crowdfunding Platform to connect Zakat givers with Zakat collectors across India. With most Muslims giving Zakat in Ramzan, and with the lockdown

due to the current Covid-19 crisis, IndiaZakat has been a perfect platform that ensures that Zakat would reach the deserving as per the requirements of the Zakat giver, while maintaining the norms of social distancing. IndiaZakat has drawn inspiration from similar centralized Zakat collection and disbursement platforms as well as crowdfunding platforms across the world (Punekar News, 2020).

4.5. Maldives

The Maldives is an archipelagic state in South Asia, situated in the Indian Ocean. Comprising a territory spanning roughly 90,000 square kilometres (35,000 sq mi) including the sea, land area of all the islands comprises 298 square kilometers (115 sq mi), the Maldives is one of the world's most geographically dispersed sovereign states and the smallest Asian country as well as one of the smallest Muslim-majority countries by land area and, with around 557,751 inhabitants, the 2nd least populous country in Asia (<https://www.britannica.com/place/Male-island-Maldives>).

In recent years, Maldives has emerged as a role model of institutionalization of zakat. Maldivians are required to submit Zakat al-Mal to Maldives Inland Revenue Authority (MIRA). As such, individuals can pay the amount or review the amount to be paid as Zakat al-Mal on the official website. Maldivians were previously required to submit Zakat al-Mal to the Islamic ministry. However, the government transferred the responsibility of collecting Zakat al-Mal to MIRA in 2016 (<https://psmnews.mv/en/115186>). In addition to the Taxpayer Service Centre, zakat al-mal can also be paid at one of the branches or collection centers of MIRA established outside Male' City. If an island does not have a MIRA office, zakat-al mal can be paid at the Secretariat of the Local Council of that island. Even though zakat al-mal is collected at MIRA, zakat al-Fitr continues to be collected at Ministry of Islamic Affairs. (MIRA, 2023; <https://www.mira.gov.mv/Pages/View/whatiszakatalmal>).

Ministry of Islamic Affairs periodically reviewed the Nisab of Zakat al Maal. In Maldives, Nisab is calculated using the price of Silver in the market. Moreover, the price of Silver is announced by the central Bank of Maldives, MMA. Most Recent price of a gram of Silver is MVR11.7 and the Nisab in Silver is 595grams. Before 9th December 2020, the Nisab was set as MVR 4950.40 and from 09th December 2020, it has changed to MVR6961.50 by ministry and the current nisab of zakat al-mal is MVR 7062.65 (USD 458.66) (<https://www.gov.mv/en/news-and-communications/nisab-of-zakat-al-maal-reviewed>)

Maldives collects USD 6 million as Zakat-al-Mal in 2022. According to the latest statistics released by Maldives Inland Revenue Authority (MIRA), Zakat al-Mal collection stood at USD6 million last year. which is a significant increase compared to the USD 5.9 collected in 2021. Ministry of Islamic Affairs reduced the Nisab for Zakat al-Mal from USD 469 to USD 373 in September (<https://psmnews.mv/en/115186>).

The Ministry of Islamic Affairs collects Zakat-Al-Fitr. In 2020, amidst the coronavirus pandemic, the ministry decides to collect fund through online from the Greater Malé Region. The ministry has returned to accept Zakat payment through the ministry's hall. The amount for Zakat is deemed to be money worth 2.4 kg of rice grain per person. Islamic Ministry said that one must donate money worth 2.4 kg of the general type of rice grains used by the individual throughout the year. The average person in Male' has to pay MVR 15 per person if calculated with normal rice grains, MVR 48 if its Thai rice grains, MVR 105 if its Basmati rice, MVR 65 if it is red rice, MVR 12 for normal flour and MVR 55 for Atta flour, as Zakat al Fitr (<https://raajje.mv/76220>).

4.6. Nepal

Nepal is a landlocked country in South Asia. It is mainly situated in the Himalayas with a diverse geography including Mount Everest, the highest point on Earth. Nepal is a multi-ethnic, multi-lingual,

multi-religious and multi-cultural state and Kathmandu is the nation's capital and the largest city. Nepal is with an area of 147,516 km² (56,956 sq mi). According to the 2011 census, Nepal's population was 26.5 million, almost a threefold increase from nine million in 1950. The 2011 census reported that the religion with the largest number of followers in Nepal was Hinduism (81.3% of the population), followed by Buddhism (9%); the remaining were Islam (4.4%), Kirant (3.1%), Christianity (1.4%) and Prakriti or nature worship (0.5%) (National Census, 2011, pp. 4, 184).

Muslims make up an estimated 4.2 percent of Nepal's population of approximately 29 million, making them the country's second largest religious minority. Most Muslims in Nepal are Sunni and of the Hanafi school of law, though there is a growing number of Muslims affiliating with the Ahl-e Hadis school and there are also small numbers of Shia Muslims in the southwest of the country (Sijapati, 2011).

Although they make up 10 per cent of the population, Nepal's Muslims are under-represented at the decision-making level. There is no mention of 'Muslim' in the constitution, so they do not have identity. Muslims are demanding a reservation policy to ensure proportional representation in every state mechanism, not only in the central administrative system but also at district and village levels (Nepali Times, 2009; (<https://archive.nepalitimes.com/news.php?id=15711#.ZBn2knZBzIU>)).

The presence of zakat in the Muslim society of Nepal is not well-documented. This researcher finds Sharma (1994) which states that the Churaute hill Muslims follow circumcision and ritual burial of the dead, but other practices like nikah (bride price) and zakat (charity collected during religious festivals) are unequally observed (Sharma, 1994, <https://www.himalmag.com/how-the-crescent-fares-in-nepal/>).

International zakat organizations have expanded their zakat activities in Nepal in recent years. For example, Zakat Foundation of America provides Nepal's impoverished with three crucial programs: Orphan Sponsorship, Water, and Seasonal Islamic Giving. The most important of these is our growing and developing Orphan Sponsorship Program where we supply full financial relief and care for orphans (<https://www.zakat.org/our-work/where-we-work/nepal>).

Another case I find is Rumah Zakat Indonesia which started working in Nepal in 2015 when the biggest disaster strike Nepal which left 9,000 people dead and 2.8 million in need of humanitarian aid. As a respond, Indonesian Rumah Zakat gave food aid and Super-qurban for Nepal earthquake victims (<https://www.rumahzakat.org/en/nepal>)

Al-Ehsan Charitable Foundation (Nepal) are dedicated to work for the wellbeing of the needy orphan children, providing aid to the poor during natural disasters and developing infrastructure for clean drinking water in remote areas. The Foundation collects zakat from local and international sources to distribute food among poor families and provide educational facilities of the orphans (<https://ehsanfoundation.org/product-category/zakat-eligible/>)

This researcher also finds a Facebook page entitled Zakat Foundation of Nepal with 510 followers. The page was created in June 201. The motto of the group is to work for humanity and equality. It has a website (<http://zakatnepal.org/>). For details about Zakat Foundation of Nepal, please visit https://www.facebook.com/ZakatNepal/about_details.

4.7. Pakistan

Pakistan, officially the Islamic Republic of Pakistan, is a country in South Asia. It is the world's fifth-most populous country and the second fifth-most populous country among OIC countries with a population exceeding 212.2 million. It is the 33rd-largest country by area, spanning 881,913 square kilometers. In Pakistan, Social protection is a recent development as an area of government intervention. Formal safety net program can mainly be categorized into two. The first category is more specific to

the formal labor sector such programs involving contingencies of sickness, old age and work-related injury (Sayeed, 2004). The second category's scope is much broader and more generic, with programs geared towards those outside the labor market and the poor and indigent. The Benazir Income Support Program (BISP), the *Zakat* Program (ZP) and the Pakistan *Bait-ul-Mal* (PBM) program are the three largest programs in the second category. Thus, the Ministry of Religious Affairs has appeared as one of the primaries implementing agencies for the major public safety net programs such as *Zakat* and *Ushr* (*Zakat* Program); the *Bait-ul-Mal* Food Support Scheme.

They find political motivations as the main driving force behind the *Zakat* Program, one of the largest safety net programs in Pakistan. ZP was initiated in 1980 by a government that adopted an overtly religious model of governance.

Khan and Qutub (2010) provides a political economy analysis of gender and social protection in Pakistan with a focus on the BISP and the *Zakat* Program. The *Zakat* Program was initiated in 1980 under the *Zakat* and *Ushr* Ordinance by the government of Zia-ul-Haq. Khan and Qutub (2010) states that at the time, there appeared to be no economic or special social protection motivations behind the program's initiation. Rather they find political motivations as the main driving force behind the *Zakat* Program. For many years, the government of Pakistan imposed a 2.5% tax levy (a wealth tax) on specified financial assets of individuals such as bank deposits worth more than a certain amount (ADB, 2002). *Zakat* used to be deducted at source and siphoned to a Central *Zakat* Fund kept by the State Bank of Pakistan. However, since 1999 the Supreme Court has made the payment of *zakat* to the state voluntary.

The *Zakat* Program is organized on a five-tier system operating under the Ministry of Religious Affairs, *Zakat* and *Ushr*. The tiers include the Central *Zakat* Council, provincial *zakat* councils, district *zakat* committees, *tehsil zakat* committees and LZCs. The *zakat* collected by financial institutions is deposited in the Central *Zakat* Fund maintained by the State Bank of Pakistan. A portion of this is retained by the Central *Zakat* Council, an autonomous agency, which is invested in on a non-interest basis. According to the ministry of Religious Affairs Pakistan, Rs.3, 951.667 million has been distributed in bulk amongst the provinces till March 2013 and other administrative areas.

There are three types of programs, including Regular *Zakat* Program, Other *Zakat* Programs and Special *Zakat* Programs. The *Guzara* (Subsistence) Allowance is the principal program and about 43% of total funds were allocated to this in 2006/07. Beneficiary households receive a monthly transfer of Rs. 500 under this scheme. Regular *Zakat* Programs also include education stipends; stipends for students of *deeni madaris* [religious schools]; health care; social welfare rehabilitation; and marriage assistance to women who are about to get married. Other *Zakat* Programs include the Eid Grant and the Leprosy Patient Program. Special *Zakat* Program consist of technical educational stipends. Permanent rehabilitation grants, which started in 2001/02 with the objective of transferring larger lump sum grants of Rs. 10,000-50,000 to help the vulnerable address their problems on a permanent basis, have now been discontinued owing to lack of funds.

The *Guzara* Allowance (a cash transfer) is by far the largest among the programs (in terms of coverage and resource use). This implies resources for the other targeted interventions (would could potentially have a greater impact) are much smaller. Remaining resources are spread thin and wide across the remaining sub-programs, diluting their impact. With payments to the program now voluntary, and with large public mistrust, the program's funding is in jeopardy, with both *zakat* levy collections decreasing and program reserves drying up. Contributions to the *Zakat* Program have observed a substantial decrease, from 0.3% of GDP in the 1980s to 0.08% in 2002/03 (World Bank, 2007). This is one reason why the number of beneficiaries declined from 1.7 million in 2001/02 to 1.6 million in 2003/04 (Issues and Policies Consultants, 2004).

Another evidence of resource constraint for this program is provided by the fact that offices are often concentrated in better-off localities. *Zakat* committees are also more active in communities that were relatively well-off (prior to the program being initiated). This difference is even more marked in rural communities. The program was found to be more likely to cover areas that had developed infrastructure and where other development programs were also active, hence it is likely that the program reinforces regional discrimination.

The *Zakat* Program also suffers from poor information dissemination. A study revealed that nearly all *Guzara* Allowance beneficiaries interviewed were unaware of the other benefits available under the program (Khan, 2008). One LZC member revealed that they deliberately did not announce facilities available under the program as they would be inundated with requests (from eligible persons). The LZC therefore itself approached people it knew to be deserving of a particular facility, such as the *zakat* for health expenses. Urban populations were especially uninformed of existing government social programs and *zakat* benefits.

There are two main impediments to participation of females and other beneficiaries in the system. The first relates to the requirement for a bank account to access funds transferred in the form of cheques. Opening bank accounts is a challenge for recipients, as most banks are not willing to keep accounts of *zakat* recipients. Others insist on a minimum balance that is too high given the small amounts being received. Despite an official circular notifying private banks that a minimum balance of Rs. 100 should be considered sufficient for *zakat* beneficiaries, this provision is largely ignored.

To address the weaknesses in the *Zakat* Program, the Ministry of Religious Affairs, *Zakat* and *Ushr* has undertaken a number of implementation reforms as follows:

1. Introduction of a new computerized mechanism to monitor and oversee *zakat* collection and disbursements;
2. Central *Zakat* Council to be brought under the chairmanship of a serving judge of an apex court;
3. Initiation of a media campaign by the ministry to encourage the public to make donations to the Central *Zakat* Fund;
4. Ministry to prepare a revised budget for the program;
5. Microfinance initiatives to be undertaken in collaboration with the State Bank of Pakistan;
6. Hospitals to receive a 'huge amount' from the ministry to treat deserving patients;
7. Ministry to give life insurance to one member (head) of beneficiary families;

[Khan and Qutub \(2010\)](#) noted that most of these reforms reflect policy decisions, and it is unclear whether there is bureaucratic commitment or political interest in ensuring their implementation. Hence, it is observed that the majority of the Muslim population prefers to administer *zakat* themselves or to give to private organizations. Despite the limitations, *Zakat* plays a very crucial role in the reduction and alleviation of poverty. [Sirur \(2020\)](#) reports that *zakat* is helping Pakistan fight its coronavirus battle. Several people in Pakistan are offering to donate their *zakat* to the poor and needy who are especially vulnerable to the novel coronavirus. The *zakat* is usually given around Ramzan and is obligatory for financially sound Muslims. However, charitable organizations, hospitals, and even Pakistan's top religious authority, the Council of Islamic Ideology, have called upon the Pakistan's rich to donate their *zakat* early because of the novel coronavirus. Several organizations are using the donations to feed the hungry and provide medical assistance to those who need it. [Transparent Hands \(2020, website\)](#) lists the top 10 *Zakat* accepting organizations in Pakistan where people usually donate their *Zakat* money in order to fulfill their religious and social obligations. These are:

1. Transparent Hands: a non-profit organization to tackle the major healthcare issue of Pakistan. It raises funds through a unique Crowdfunding platform.
2. Shaukat Khanum Cancer Hospital: one of the largest charity organizations of Pakistan, established by Imran Khan, Cricketer-turned-politician and the current Prime Minister.
3. Edhi Foundation: One of the most internationally known foundations founded by Abdul Sattar Edhi in 1951. It offers services include accommodation for destitute, handicapped and orphans etc.
4. Chhipa Welfare Association: one of the very efficient charity organizations in Pakistan, it was founded in 2007 by Ramzan Chhipa. a non-profit NGO's which is serving humanity without any discrimination of caste creed or color.
5. Aurat Foundation: Established in 1986, as a national, non-profit and non-governmental charity organization to mobilize public pressure for women's empowerment in the country.
6. EHSAS: an NGO based in Chakwal and Islamabad. Its projects target a wide range of areas including poverty alleviation, healthcare, education and social development.
2. The Rising Sun: formulated by Mr. & Mrs. Abdul Tawwab Khan in 1984. It provides services like education, physiotherapy, speech therapy, sensory and hydro integration therapy, physiotherapy and speech therapy to children with intellectual cognitive impairment cerebral palsy and autism and vocational training etc.
3. The Citizen Foundation: one of the largest non-profit organizations in the field of education. It was established back in 1995.
4. Care Pakistan: founded in 1988 by Seema Aziz to educate 1/9 million kids.
5. The Sindh Institute of Urology & Transplantation: started its journey almost 4 decades ago in Karachi. the institute is well appreciated for renal transplantation and related diseases.

4.8. Sri Lanka

Sri Lanka, officially the Democratic Socialist Republic of Sri Lanka, is an island country in South Asia, located in the Indian Ocean southwest of the Bay of Bengal and southeast of the Arabian Sea. It is geographically separated from the Indian subcontinent by the Gulf of Mannar and the Palk Strait. Sri Lanka has roughly 21.67 million population (World Bank, 2018) and a total area of 65,612 km², with 62,707 km² of land and 2,905 km² of water. Sri Lanka is a multi-religious country. Buddhists comprise 70% of the population. Hinduism is the second most prevalent religion. Islam is the third most prevalent religion in Sri Lanka. As a minority religion, 9.7% of the Sri Lankan population practice Islam. 1,967,227 persons adhere to Islam (Government of Sri Lanka, 2012) Islam has first been brought to the island by Arab traders over the course of many centuries, starting around the 7th century CE. Most Muslims are Sunni who follow the Shafi'i school.

Jalaldeen (2015) states that there is no any provision or imposed act in *Zakat* management in Sri Lanka. However, charity plays a central aspect of the religious orthopraxy of Sri Lankan Muslims (Osella, Stirrat, & Widger, 2015). In several villages, towns where the Muslims are living with majority population, the work of gathering and distributing of zakat is taking place by Muslim's voluntary sectors such as "Zakat Funds", Mosque federations and Dawah movements (Jalaldeen, 2015). Whilst the annual giving of *zakat* is an obligation for those who hold wealth or assets above a certain amount, *sadaqa* is a form of meritorious giving practiced by every Muslim. Sadaqa, for instance, can entail something as substantial as donation of money to build a hospital, or as insignificant as removing a stone from a footpath (Osella, Stirrat, & Widger, 2015).

Osella, Stirrat, and Widger (2015) shows that through Muslims prefer anonymous giving, in many cases, anonymity is difficult because giving remains a highly socially-embedded activity. People continue to personally give *zakat* and *sadaqa* to those with whom they have long-term relationships.

Osella, Stirrat, and Widger (2015) also finds that the mainstream Sunni majority forms *zakat* committees by involving informal groups of people connected through friendship, university education, profession or business. They collect *zakat* and *sadaqa* for specific purposes - for example, the provision of educational scholarships, basic housing and sanitation, and the support of (rural) employment schemes. Supporters of various reformist organizations argued that 'a poor Muslim cannot be a poor Muslim', and were hopeful that with more co-ordination and planning *zakat* and *sadaqa* would lift all Sri Lankan Muslims out of poverty.

Osella, Stirrat, and Widger (2015) finds complexity in the case of distributing *zakat* because *zakat* must be given by Muslims to Muslims. So, there is donor concern about the 'real' identity of doorstep beggars and there are rumors that *professional* beggars try to pass themselves off as Muslims in order to receive *zakat* during *ramzan*. On the other hand, a number of foundations associated to prominent Muslim businessmen extend their charitable activities to anyone in need, regardless of religious or ethnic affiliation as there is no restriction for choosing *sadaqa* beneficiaries. In practice, it is seen that donations in kind or cash are moving from Colombo to the donors' natal or ancestral village as donors prefer to help the close relatives and neighbors.

Osella, Stirrat, and Widger (2015) found that cash is the most appropriate form of donation. However, there are donors who are concerned with the *transformation* of the lives of those who receive charity, and, thus, they donate to meet specific needs – for example, providing appropriate sanitation or building low-cost housing. In practice, donors are seldom fixed on one form of giving alone, preferring instead to spread their donations. The most common practice is to continue responding to demands from individuals – not only beggars, but also those unable to meet the expense of medical emergencies, life-cycle rituals, education, and utilities bills – and to support religious institutions, whilst giving a proportion of one's donations to various religious and non-religious charitable organisations.

Jalaldeen (2015) conducted a field study on Zakat management in Maruthamunai, a village in Amparai district with 100% of Muslim population. In these 4 square km villages, 4968 families with 16435 persons lived. [Planning Division of Kalmunai DS Office]. The main occupations of these people are weaving, fishing, Agriculture, Trade and employment in government and private sectors as well as employment in abroad. 1574 families of Maruthamunai are getting only less than 5000 Sri Lankan rupees as monthly income and 1368 families are with 5000-10000 rupees income. So, nearly 60 per cent of the families in Maruthamunai are eligible to receive *zakat* payments according to the Islamic *Shari'ah*. The Zakat management has been practiced as an institutional level for last twenty years at this village with the coordination of Mosques Federation and some Dawah movements. According to the report submitted by *zakat* fund committee on April 1996, it was collected 210,150 Sri Lankan rupees from 117 *zakat* payers. Since then, Zakat collection has been increased periodically and distribution of *zakat* fund was held every year as they started in beginning. In 2014/2015, according to database prepared by *zakat* fund committee of Maruthamunai, approximately 4.7 million Sri Lankan Rupees have collected as *zakat* fund. However, the committee has not kept prepared a rules and regulation or criteria to distribute the *zakat* collection. The committee called application from eligible persons to receive *zakat* collection. The Table-4.2 exhibits the Zakat distribution among recipients, Maruthamunai as follows.

Table 4.2: Zakat distribution among recipients, Maruthamunai

S. No	Distributed item	Numbers	Amount
01	Sewing machine	05	Rs. 30,000
02	Weaving employment	03	Rs. 18,000
03	Small business	07	Rs. 28,000
04	Firewood business	06	Rs. 24,000
05	Rice Business	04	Rs.8,000
06	Mat works	02	Rs. 3,000
07	Hoppers making	02	Rs.2000
08	Small industrial	09	Rs. 24,000
09	Livelihoods	22	Rs.9,500

Source: [Jalaldeen \(2015\)](#) [Report of zakat fund committee, Maruthamunai]

Sri Lanka as a country with minority Muslim population has a challengeable in collecting and distributing of zakat according to the state rule. If zakat is managed properly, it will certainly have positive effect on the wellbeing of Sri Lankan poor Muslims. However, Lack of coordination between all institutions of zakat management has resulted in the achievement of zakat collection and distribution does not optimum. [Jalaldeen \(2015\)](#), therefore suggests that Zakat Management is needed to collaborate with other agencies such as microfinance institutions, business corporations, and tertiary institutions to further improve their efficiency. The collaboration may revolve in vast areas including business projects, financial supports, management trainings, monitoring, and research conducts ([Jalaldeen, 2015](#)).

5. Discussion

The type of collection, organizational structure and political motives can determine the role that Zakat plays in providing support to the poor and vulnerable. This section looks at some of the main challenges and opportunities of Zakat by pointing out the main commonalities and differences across the four countries analyzed.

5.1. Financing – Zakat opening up fiscal space for social protection

The extent to which Zakat can be used to finance social protection measures varies not only in the way it is collected and administered, but also with the country's geographic and political conditions. In Pakistan, Zakat was mandatory until 1999 and reached proportionally more households than in the other countries under this study. Therefore, Pakistan's creation of a decentralized collection system had helped to ensure a steady increase in Zakat collections. Despite the vast land area and difficulties in identifying the wealth to determine the Nisab, Pakistan presents an interesting case where Zakat collection has been managed in such a way that it constitutes a crucial revenue for financing, not only in-kind and cash transfers, but also health insurances.

But now Zakat is a voluntary act of charity in the four countries. Hence, Zakat constitutes a rather small part of the national social protection systems. In Pakistan and Bangladesh, there is national zakat boards. However, it is observed that the majority of the Muslim population prefers to administer zakat themselves or to give to private organizations. The size of the state-run Zakat fund is relatively small because of a serious lack of trustworthiness and acceptability of the fund among the mass people. However, some private organizations in both Pakistan and Bangladesh have been functioning very well.

In India, zakat collection varies across the states based on the variability of the socio-economic and cultural status of the Muslims. As a result of this, Zakat circulation is within that specific area and the localized management of zakat welfare delivery system has developed. The downside of this system is

that it leads to the disparity in prosperity. The non-prosperous Muslim region continues the poor living conditions. To improve the living conditions of the Muslims across India, a professionally organized zakat system is urgently needed from collection to distribution of zakat funds.

In Sri Lanka, there is no any provision or imposed act in Zakat management in Sri Lanka. However, in several villages, towns where the Muslims are living with majority population, Mosque federations and Dawah movements organize “Zakat Funds” voluntarily. Supporters of various reformist organizations are hopeful that with more co-ordination and planning *zakat* and *sadaqa* have a great potential to lift all Sri Lankan Muslims out of poverty.

5.2. Selection of beneficiaries – ensuring that those most in need receive Zakat

While the Quran establishes the eight categories for those who should receive Zakat, the selection is at the discretion of the Funds’ administrators. In Bangladesh, the government's higher authority has a lack of focus on Zakat collection. Limited manpower is a major challenge for raising a substantial amount of Zakat. The selection of beneficiaries of State-run Zakat Fund in Bangladesh is ultimately made on ad-hoc basis and nepotism. Where private zakat bodies like Center for Zakat Management (CZM) have shown some successes in mobilizing and disbursing Zakat in an institutionalized management process. Since 2008, CZM has been successfully prospering the livelihood of over 400,000 people. So, it is said that CZM has been to some extent inclusive in terms of selection of beneficiaries.

In Pakistan, the number of eligible zakat recipients are too large that local zakat committee (LZC) deliberately did not announce facilities available under the zakat program. The LZC therefore itself approached people it knew to be deserving of a particular facility, such as the zakat for health expenses. Urban populations were especially uninformed of existing government social programs and zakat benefits. Disbursing zakat through bank accounts has been a major impediment to participation of females and other beneficiaries in the system. In India and Sri Lanka, zakat donations in kind or cash are moving from cities to the donors’ ancestral village as donors prefer to help the close relatives and neighbors.

5.3. Integrating Zakat into the broader national social protection system

In the four countries analyzed, a state institution supervises the respective Zakat Funds in two countries-Bangladesh and Pakistan. Whereas, in India and Sri Lanka, there is no state institution to supervise Zakat Management, rather there has been community-based Zakat Funds. When looking at the integration of Zakat into national social protection systems, one can observe that, in Pakistan, the Zakat Program (ZP) and the Pakistan Bait-ul-Mal (PBM) program have been implemented by the Ministry of Religious Affairs. So, in Pakistan, Zakat, Ushr and Bait-ul-Mal have appeared as the major public safety net programs and displayed a signification in the country’s Poverty Reduction Strategy and social safety net programs. Nevertheless, the case of Pakistan also shows that a clear vision for institutional coordination and the sharing of information across different institutions is needed to avoid overlaps, which could also help to integrate the different services better. In Bangladesh, through there is state-run zakat fund, zakat has not been a part of poverty reduction strategy and social protection due to the lack of comprehension by the policy makers as well as lack of political will. In fact, both cases of Bangladesh and Pakistan show that a better coordination with other government institutions could help to ensure that the most vulnerable are indeed reached. Moreover, the selection of beneficiaries and administration of resources is often not very transparent and it is difficult to obtain up-to-date information. An independent audit institution could help in increasing the transparency and accountability of Zakat Funds.

5.4. Digitalization of Zakat

To stop selecting beneficiaries based on a case-by-case basis and to enhance inclusivity of people in need on a transparent manner, it has the advantage of relying on an electronic database. Digitalization of zakat can help ensure that those most in need are reached through a readily accessible database. Anyone can check clear criteria for the selection of beneficiaries very easily.

This covid-19 pandemic has taught us the importance of digitalization because social distancing is one of the measures to contain the pandemic. the proper digitalization in many cases can ensure social distancing.

It is worth noting that Crowdfunding Platform to disburse Zakat and Relief Payments Digitally have been introduced in Bangladesh, India and Pakistan to prevent the further spread of the Coronavirus through ensuring social distancing and other precautions by way of the digital disbursement of funds. In Bangladesh, on May 15, 2020, 'Ek Dosh', the first Crowdfunding FinTech Platform in the country has been launched to disburse Zakat and Relief Payments Digitally. The a2i Programme of the ICT Division developed the platform to ensure the amount donated will reach the underprivileged population of the country. The Prime Minister's Emergency Relief Fund for Covid-19, the Islamic Foundation, BRAC, Bidyanondo Foundation, Center for Zakat Management, CRP and Sajeda Foundation are incorporated in this platform (A2I website, 2020). In India, Association of Muslim Professionals (AMP) has launched "IndiaZakat.com" to connect Zakat givers with Zakat collectors across India. In April, Pakistan's Easypaisa, a local provider of online financial services, teamed up with Zakat and Ushr department of the Government of (the province of) Punjab, in order to distribute funds to locals who have been impacted by the Coronavirus (COVID-19) outbreak and resulting economic slowdown due to a nationwide lockdown (Faridi, 2020).

6. Conclusions

Zakat, the religious duty to give a certain amount of one's wealth to those in need, has played an important role in providing social assistance for centuries. Zakat Funds are increasingly more institutionalized and are part of many countries' social protection systems; providing cash, food, health and education services to the poor. This paper discussed the Zakat Funds in South Asian countries. A number of key messages can be taken away from these case studies:

- Among the countries under the case study, Maldives has emerged as the role model in recent years in terms of institutionalization of zakat through state mechanism. It is noteworthy to further research on the impact of state collection of zakat al maal in the society especially in enhancement of social protection.
- There is no one-size-fits-all solution in terms of institutionalization of Zakat, yet a decentralized system has shown to be an important feature. The case of Pakistan demonstrates that local Zakat Committees play an important role in collecting and distributing Zakat on the community level. Whereas, In Bangladesh, government zakat body has lack of manpower and are ineffective in zakat collection and disbursement.
- Implementing an efficient collection system is also crucial to increase funding, yet the mechanisms to develop it (i.e., through a mandatory tax or voluntary transfers) are context-specific and need to be carefully evaluated, considering both advantages and disadvantages. For example, a mandatory system can help to increase Zakat resources but, at the same time, it can decrease people's trust in Zakat since they have always perceived it as a religious duty that people used to pay themselves without interference by the state.

- Improving coordination among state institutions is crucial to enhance the role of Zakat Funds as providers of social protection. For this, it is crucial that databases are shared and all relevant stakeholders collaborate. However, shared databases require a minimum of infrastructure and know-how as well, which take time and resources to establish. The commitment of all relevant stakeholders is also not a given and requires consensus-building.
- Although the potential of using Zakat Funds as a major source to increase fiscal space for social protection, the volatility of funds, especially when collection systems are voluntary, rises as a matter of attention, as the case of Pakistan shows. Predictability of contributions is deemed central for the effectiveness of programs as regular and adequate transfers are key to bring people out of poverty.
- In this pandemic time, digitalization of zakat through crowd funding platforms have been a cutting-edge technology solution to the financial sector to disburse Zakat (charity) funds to those who are struggling to meet basic personal needs during these challenging times.
- Future research should focus on coverage and targeting analysis by investigating who is not yet covered by Zakat (and other state-provided services) and where they live. Likewise, it is relevant to analyses whether or not some vulnerable groups have less access to Zakat than others (e.g., religious minorities and refugees).
- When considering the overall context of subsidy reforms in South Asia and increased redistribution of social spending into more targeted assistance measures (as illustrated in the case of Pakistan), Zakat-funded schemes have shown to be important mechanisms to support new poverty-reduction strategies. Indeed, as stated in this paper, Zakat has been an increasingly relevant institution to promote wealth redistribution and poverty reduction. It is, however, important that the provision through Zakat Funds does not lead to a shifting of responsibilities, away from the State. Zakat and traditional state-provided social protection should complement each other, yet the former should not replace the latter.

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**Smartphone Usage and Self-reported Well-being in Children:
A Study in Rajshahi City, Bangladesh**

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Effects of Excessive Smartphone Use on Child Health in Rajshahi City, Bangladesh

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Abstract

Globally, the use of smartphones has been increasing rapidly in recent years which has both benefits and health effects. This study aims to identify the factors associated with the excessive use of smartphones and to determine the health effects of excessive smartphone use on children in Rajshahi City, Bangladesh.

Methods

This cross-sectional study considered a total of 473 students of classes VIII to X aged 13-18 years from Rajshahi City, Bangladesh. Data were collected through a self-reported structured questionnaire using a multi-stage stratified sampling technique. Patient Health Questionnaire-9 (PHQ-9) was used for self-reported well-being. Self-reported well-being of the respondents is considered as the response variable and time spent on smartphone is considered as the explanatory variable. Both bivariate (χ^2 – test) and multivariate (binary logistic regression model) analyses were used to reach the objectives.

Results

The children, including boys 190 (40.2%) and girls 283 (59.8%) with an average age of 15.40 ± 1.38 years, among them around one-third ($n = 151, 31.9\%$) excessively used smartphones. Children's age, gender academic grade, family type, father's education, father's occupation, mother's age, mother's education, mother's occupation, family income, smartphone ownership, mode of internet connection, and playing hours were found significantly associated with the excessive use of smartphones. In the case of health effects of the children, excessive use of smartphones is identified as the significant determinant of 'feeling anxiety', 'little interest or pleasure in doing things', 'feeling down, depressed, or hopeless', 'feeling tired or having little energy', 'feeling bad about yourself - or that you are a failure or have let yourself or your family down', 'trouble concentrating on things, such as reading the newspaper or watching television', and 'thoughts that you would be better off dead, or of hurting yourself in some way'.

Conclusions

A good number of factors are associated with the excessive use of smartphones, which had various health effects. Appropriate interventions should be taken that target problematic smartphone use which could thus potentially reduce the children's health effects.

Keywords

Smartphone; Mobile applications; excessive use of smartphones; self-reported health effects; PHQ-9

1. Background

A smartphone (a portable device that combines integrated computer and other features) is a cell phone that allows users to make phone calls, send text messages, browse the internet, and run software programs. It has been becoming popular since earlier in the 21st century, and it is now considered a vital part of our daily lives [1]. The rapid advancement in technology has made many implements, a smartphone is one of them. Moreover, smartphone use is becoming cheaper and cheaper because of competition among network providers as well as phone companies, which lead to increased use of smartphone among all parts of the population. Nowadays, smartphone users are increasing drastically across the world. According to Statista, in 2023, globally the current number of smartphone users is 6.92 billion, meaning 86.34% of the world's population owns a smartphone. This figure is up considerably from 2016, when only 3.668 billion users were 49.40% of that year's global population. In Bangladesh, mobile phone users have increased from 81.7% in 2013 to 89.9% in 2022; 97.4% households have mobile phones and the number of households with a smartphone is 2,21,93,311 [2]. The number of secondary school students in Bangladesh is 8,93,0245 (girls student: 54.92) [3]. Thus, a study among secondary school students and smartphone use should be concern.

In our everyday life, smartphones are used through different activities, which containing Wi-Fi technology have a key role in exchanging information and data to show images, audio, videos, and transfer applications from mobile emit radio waves [4-6]. However, the excessive use of smartphones has become an emerging health issue. The human body may absorb part of these emitted waves, especially when a voice call is made [7, 8]. The health and biological effects of the emitted waves occur mainly in the head and neck areas [9, 10]. The cause is that the frequency of radiations emitted from the mobile is utilized in a range from 3 kHz to 300 GHz [4]. Children are often using Wi-Fi services available on mobile devices, and they are often more vulnerable to the impact of radio microwaves because their skulls are thin and contain high fluid, their nervous systems still develop, the increased activity of cell division in their bodies, plus weakness of their immune response. Consequently, the higher number of smartphone users without restriction becomes an emerging public health issue [11]. Especially, children's smartphone use concerns exist regarding excessive use and the impact of frequent consumption of mobile media on children's health and welfare [12, 13]. There are numerous studies identified the potential health and psychological effects of smartphones on the developing brains of children [14, 15], increased upper extremity muscle activity and caused greater upper trapezius pain [16], neck problem [17], hand pain [18], memory performance [19, 20], emotional and behavior difficulties [11, 21], etc.

Many factors may be related to increased risks of physical and psychological healths, and several are especially prevalent for the children in the stage of emerging adolescents (10-19 years old). In the recent years, the difficulties of children's smartphone use have paid attention and it has been a growing concern for the ways that children have increased access to smartphone technology. Specifically, the behavioral concerns of smartphone addiction in children have paid attention globally. The routine and frequent use of mobile devices appear to be associated with behavioral problems in childhood [22, 23]. Again, some recent studies [11, 24] have turned toward the adverse bodily effects that smartphones can have on children. In this regard, the World health Organization (WHO) has focused on its need to conduct numerous research since 2006. In Bangladesh, a few studies are focusing on smartphone use and health risk. The previous studies contributed to our knowledge on excessive use of smartphones, for their research in this domain is warranted. Again, to formulate policy recommendations that enhance children's welfare, there is a growing need for reliable evidence to assess the factors associated with smartphone use and the adverse health effects of excessive smartphone use in children. Therefore, the specific objectives of this study are to identify the factors associated with the excessive use of

smartphones and to determine the health effects on children in Rajshahi City, Bangladesh. It is expected that the study findings would be very beneficial in revealing the treatment evidence of disease entities for smartphone addiction.

2. Methodology

2.1. Data collection

The study utilized a cross-sectional study design and was conducted out between October and November, 2022. Data were collected from Rajshahi City, Bangladesh by following a multi-stage stratified random sampling technique. In the 1st stage, Rajshahi City was selected purposively (out of 12 city corporations); in the 2nd stage, five wards were selected randomly (ward numbers: 8, 12, 20, 24, and 29) (out of 30 wards), in the 3rd stage, five secondary schools from those five wards were selected randomly for data sources; and in the 4th stage (final stage), the respondents were selected from classes VIII to X aged 13-18 years. However, the children within the 13-18 years age bracket who had some forms of physical disability were not included in this study. To select the schools, a list of educational institutions generated by the Government of Bangladesh (GoB) was used as the sampling frame. In case of sample size selection, it has been determined by using the following formula [25]:

$$n = \frac{Z^2 p(1-p)}{\epsilon^2} = \frac{Z^2 pq}{\epsilon^2}, \quad (1)$$

where, n = sample size, Z = tabulated value = 1.96 (at 5% level of significance), p = portion of success (assuming that, $p = 0.5$), q = portion of failure = $1 - p$, and ϵ = margin of error = 0.05. Based on the above formula (Eq. (1)), the study was supposed to select 384 respondents, but for the betterment of research 473 respondents were considered for this study.

A structured questionnaire was used to collect data from the respondents. A pilot survey was conducted prior to finalizing the questionnaire. The questionnaire included three parts (*viz.*, i. socio-demographic information, ii. information on smartphone use, and iii. self-reported physical symptoms). The questionnaire was first developed in English and later it has been translated into native language (Bangla) for the respondents. To collect data, the self-reported questionnaires were distributed among the students of classes VIII to X. In this regard, prior permission was taken from the head of the institution. The enumerators were provided a briefing to the students about the purpose of this study and the process to fill up the questionnaire. The students were carried out it to their residences to fill up the questionnaires after seeking permission from their parents (or guardians) and they were sent back to the enumerators on the subsequent days. In some cases, respondents' parents (or guardians) or respondents were asked regarding to fill up the questionnaire properly.

2.2. Exposure variables

The explanatory variable was daily time spent on a smartphone in hours through phone calls, video games, Facebook, YouTube, etc. The cut-off point was considered based on current recommendations to limit daily spent time on using smartphones to a maximum of 2 hours [26-28]. Thus, daily time spent on smartphones ≤ 2 hours is termed as normal use and > 2 hours is termed as excessive use. Other explanatory variables considered were students' age, sex, academic grade, family type, number of family members, number of siblings, birth order, place of residence, father's age, father's education, father's occupation, mother's age, mother's education, mother's occupation, monthly family income, having internet connection, mode of internet connection, and playing hours per day. Above variables were found significantly associated with the time spent on smartphone use in previous studies [28-31].

2.3. Outcome variables

This study considered a range of outcome variables related to self-reported well-being in children, which were classified into two types (Type I, Type II) of questions. Type I included ‘headache due to smartphone use’ and ‘feeling anxiety’; and Type II included the Patient Health Questionnaire-9 (PHQ-9) (except items 3 and 8). The PHQ-9 is a self-reported questionnaire consisting of 9 items matching the Diagnostic and Statistics Manual of Mental Disorder-Fifth edition criteria of major depression [32]. Each item is used to evaluate feelings in the past 2 weeks. Response options ranged from “not at all = 0” to “nearly every day = 3.” These 7 questions were further categorized as ‘not at all’ (coded 0) and ‘sometimes’ (for ‘several days’ or ‘more than half of days’ or ‘nearly every day’) (coded 1).

2.4. Statistical analysis

Univariate (descriptive statistics), bivariate (χ^2 – test), and multivariate (binary logistic regression model) analyses were used to analyze the data. Descriptive statistics (frequency, percentage, mean, and standard deviation [SD]) were used to find the background characteristics of the respondents. The χ^2 -test was used to find the associations between time spent on smartphone use (normal use vs. excessive use) with socio-demographic factors (including smartphone related factors) and self-reported well-being. The effects of time spent on smartphone use on the self-reported well-being symptoms were determined after adjusting for the socio-demographic characteristics of the children. Multivariate binary logistic regression model was used for this purpose since the outcome variables were dichotomous (no, yes). Statistically significant variables were in the bivariate analysis were included in the multivariate models. Unadjusted and adjusted odds ratios (ORs) and 95% confidence intervals (CIs) were produced the logistic regression models to measure the significant associations between time spent on smartphone (normal use vs. excessive use) and the prevalence of well-being symptoms. All statistical analyses were conducted using SPSS V.22.0 (SPSS Inc, Chicago, Illinois, USA). Statistical significance was set at a p value of < 0.05 .

2.5. Ethical consideration

The Institutional Animal, Medical Ethics, Biosafety and Biosecurity Committee (IAMEBBC) of the Institute of Biological Sciences (IBSc), the University of Rajshahi, Bangladesh reviewed and approved this study (Memo No: 249(35)/320/IAMEBBC/IBSc). Moreover, informed verbal consent was obtained from the study participants after exploring the objectives of this study. The confidentiality of the participants was ensured as well.

3. Results

3.1. Descriptive statistics

A total of 473 children were considered for this study. The socio-demographic characteristics of the respondents are presented in Table 1. The higher portion of the respondents were aged 15-16 years ($n = 296$, 62.6%), girls ($n = 283$, 59.8%), in class IX ($n = 210$, 44.4%), living in nuclear family ($n = 359$, 75.9%), having 2-4 family members ($n = 226$, 47.8%), number of siblings 2 ($n = 225$, 47.6%), 1st birth order ($n = 249$, 52.6%), living with family ($n = 458$, 96.8%), and living in the urban areas ($n = 393$, 83.1%). The average ages of their fathers were 44.68 (± 6.92) years and mothers were 37.81 (± 6.01) years, and the average monthly income was 20,718.71 ($\pm 2,057.22$) taka (Bangladeshi currency, \$1=100 Taka). Smartphone- and health-related characteristics are presented in Table 2. In the case of ownership of smartphones, most of the children (70.80%) have personal smartphones or their family members have, the mean time spent on smartphone use (per day) was 1.82 (± 0.24) hours, around one-third ($n = 151$, 31.90%) children were excessive used smartphones (> 2 hours per day), and around three-fourths of the children’s (76.10%) playing hours was less than one hour (no playing, 42.01%).

The bivariate analysis (χ^2 – test) was used to find the association between ‘time spent on smartphones’ (normal use vs. excessive use) with ‘socio-demographic factors’ and ‘smartphone- and health-related factors’ of the respondents and the results are presented in Table 3 and Table 4, respectively. This analysis identified that time spent on smartphones was found statistically significantly ($p < 0.05$) associated with respondent’s age, gender, academic grade, family type, fathers’ education, fathers’ occupation, mothers’ age, mothers’ education, mother’s occupation, and family income. Again, ‘time spent on smartphones’ was found statistically significantly ($p < 0.05$) associated with respondents ‘smartphone ownership’, ‘mode of internet connection’, ‘playing hours’, ‘headache’, ‘feeling anxiety’, ‘little interest or pleasure in doing things’, ‘feeling down, depressed, or hopeless’, ‘feeling tired or having little energy’, ‘feeling bad about yourself - or that you are a failure or have let yourself or your family down’, ‘trouble concentrating on things, such as reading the newspaper or watching television’, and ‘thoughts that you would be better off dead, or of hurting yourself in some way’.

Finally, multivariate binary logistic regression models were used to examine the effects of excessive use of smartphones on self-reported well-being of the children and the results are presented in Table 5. The binary logistic regression models identified excessive use of smartphones as the statistically significant ($p < 0.05$) predictor of ‘feeling anxiety’, ‘little interest or pleasure in doing things’, ‘feeling down, depressed, or hopeless’, ‘feeling tired or having little energy’, ‘feeling bad about yourself - or that you are a failure or have let yourself or your family down’, ‘trouble concentrating on things, such as reading the newspaper or watching television’, and ‘thoughts that you would be better off dead, or of hurting yourself in some way’. The children who excessive used smartphones (> 2 hours per day) were feeling anxiety 1.859 (OR=1.859, 95% CI: 1.207-2.863) times more than that of who normal used smartphones. The children who excessive used smartphones were ‘felled little interest or pleasure in doing things’ 1.816 (OR= 1.816, 95% CI: 1.127-2.224) times more likely compared to the children who normal used smartphones. The results identified that the children who had excessive use than normal use smartphones reported a 1.767 (OR=1.767, 95% CI: 1.142-2.734) times higher likelihood of ‘feeling down, depressed, or hopeless’ and 1.827 (OR=1.827, 95% CI: 1.189-2.808) times higher likelihood of ‘feeling tired or having little energy’. Again, the children who had excessive use smartphones were ‘feeling bad about yourself, or that you are a failure or have let yourself or your family down’ 2.326 (OR=2.326, 95% CI: 1.488-3.636) times, ‘trouble concentrating on things, such as reading the newspaper or watching television’ 1.586 (OR=1.586, 95% CI: 1.035-2.430) times, and ‘thoughts that you would be better off dead, or of hurting yourself in some way’ 2.983 (OR=2.983, 95% CI: 1.823-4.880) times higher risk compared to the children who had normal use smartphones.

4. Discussion

Adolescents use smartphones in everyday life through different activities. But, their excessive use smartphones accompanies negative consequences [33]. Particularly, students are identified as the most vulnerable group of the population as they waste their most valuable time through smartphone use, which is associated with a lower quality of life, more behavioral difficulties, and poorer school performance [34]. This study examined the prevalence and potential risk factors associated with the excessive use of smartphones as well as determined the self-reported health effects in children due to excessive use of smartphones. For this, a total of 473 secondary school children of classes VIII- X were included in this study and their time spent on smartphone use more than 2 hours per day is considered as the excessive use of smartphones. This study identified that excessive use of smartphones in children aged 13-18 years to be 31.9%, which is higher than the global prevalence (26.99%) [35]. The excessive use of smartphones among students found 2.3% in Germany [28], 31% in Korea [36], 35.9% in Thailand and 12% in Japan [37]. A recent study conducted in Bangladesh and found that 61.4% of the young adults aged 18-32 years and 40.7 females were addicted to their smartphones [38]. These results

confirm our expectations that excessive use of smartphones is higher prevalent among Bangladeshi adolescents compared to their Asian peers. Possible reasons may be cultural differences and differences in the digitalization process [39]. Again, this study identified that the excessive use of smartphones is more prevalent among girls (36.70%) than that of boys (24.70%). This results also supported by a study conducted in Germany among adolescents [28].

Smartphone use time is statistically significantly ($p < 0.05$) associated with adolescent's socio-demographic factors, *e.g.*, age, sex, academic grade, family type, father's age, father's occupation, mother's age, mother's education, mother's occupation, and family income. The findings of this study are also consistent with the results of the previous research studies among adolescents [37, 38, 40, 41]. Again, smartphone use time is statistically significantly ($p < 0.05$) associated with adolescent's smartphone ownership, mode of internet connections, and playing hours (per day) as well as self-reported well-being (*e.g.*, headache, feeling anxiety, 'little interest or pleasure in doing things', 'feeling down, depressed, or hopeless', 'feeling tired or having little energy', 'feeling bad about yourself - or that you are a failure or have let yourself or your family down', 'trouble concentrating on things, such as reading the newspaper or watching television' and 'thoughts that you would be better off dead, or of hurting yourself in some way'). Finally, the binary logistic regression models identified the effects of excessive use of smartphones on self-reported well-being of the children. The findings of this study confirmed that the excessive use of smartphones as the determinant factor with similar direction of 'feeling anxiety', 'little interest or pleasure in doing things', 'feeling down, depressed, or hopeless', 'feeling tired or having little energy', 'feeling bad about yourself - or that you are a failure or have let yourself or your family down', 'trouble concentrating on things, such as reading the newspaper or watching television', and 'thoughts that you would be better off dead, or of hurting yourself in some way'.

In case of self-reported well-being of the children, this study identified that anxiety is 1.859 times more likely among the children who excessive used smartphones. In this line, Lepp et. al [42] investigated the relationships between cell phone use on Satisfaction with Life among students and identified negatively impact on academic performance, mental health, and subjective well-being or happiness. Hallauer et. al [43] examined the relationship between problematic smartphone use and anxiety among junior school and senior high school students in Tianjin, China. They found that anxiety sensitivity is positively associated with problematic smartphone use. 'Little interest or pleasure in doing things' is identified 1.816 times more like among the children who excessive used smartphones. Similar result is identified by Sharmila et. al [44] utilizing a large-scale mobile usage dataset and a PHQ-8 depression questionnaire answered by 743 respondents from different age groups and socioeconomic background characteristics. They indicated that respondents with little interest in doing things spend more of their time on smartphones. This study identified that the students who excessive used smartphones are 'feeling down, depressed, or hopeless' 1.767 times more than that of the students who do not excessive use smartphones. Other studies [45-47] also supported this result. The students who excessive used smartphones are 1.827 times more likely to feel tired or having little energy compared to the reference category (normal use smartphones).

The previous studies [48-50] identified similar findings in their studies. The present study identified that the respondents were used smartphones excessively were 'feeling bad about yourself - or that you are a failure or have let yourself or your family down', 2.326 times more than that of the students who do not use or normal use smartphones. In this regard, the studies [51, 52], 'trouble concentrating on things, such as reading the newspaper or watching television' was found 1.586 times higher among the students who excessive used smartphone. Among the most recent studies [53, 54] are also identified the similar findings. Again, this study identified that the respondents who were used smartphones

excessive were 2.983 times higher risk to ‘thoughts that you would be better off dead, or of hurting yourself in some way’ compared to the students who use normal used smartphones. In this line, the previous studies [53, 54] also identified the similar findings.

5. Conclusions

This study found the higher prevalence of excessive smartphones use among secondary school children in Bangladesh. The children had many adverse health effects through excessive use of smartphones, which has significant implications for the policy makers with respect to the health outcomes both at present and into the future. The study finding suggest that there is a need to find solutions to address the significant impact of excessive use of smartphones at a national and international levels. National and international public health organizations should develop policies and guidelines to reduce excessive use of smartphones. Furthermore, it is important to raise awareness and counselling programs of the potential long-term effects of excessive use of smartphones on the health outcomes of adolescents. In the near future, it may be considered an intervention study to reduce health risks through smartphone users.

5.1. List of abbreviations

WHO: World Health Organization, PHQ: Patient Health Questionnaire, OR: Odds ratio, CI: Confidence interval, SD: standard deviation,

5.2. Acknowledgements

This work was supported by the Centre for Strategic and Peace Studies (CSPS), Dhaka; Bangladesh.

5.3. Data availability statement

The data presented in this study are available on request from the Project Director. The data are not publicly available due to privacy restriction.

5.4. Conflicts of interest

No conflict of interest.

Table 1: Socio-demographic characteristics of the children, (N= 473)

Characteristics	Categories	<i>n</i>	%	mean±SD
Age (in years)	13-14	63	13.3	15.40±1.38
	15-16	296	62.6	
	17-18	114	24.1	
Gender	Boys	190	40.2	
	Girls	283	59.8	
Academic grade	VIII	112	23.7	
	IX	210	44.4	
	X	151	31.9	
Type of family	Nuclear	359	75.9	
	Extended	114	24.1	
Number of family members	2-4	226	47.8	5.15±2.14
	5-6	176	37.2	
	>6	71	15.0	
Number of siblings	1	74	15.6	2.36±0.99
	2	225	47.6	
	3	127	26.8	
	>3	47	9.9	

Birth order	1 st	249	52.6	
	2 nd	145	30.7	
	3 rd	58	12.3	
	≥4 th	21	4.4	
Living with family	No	15	3.2	
	Yes	458	96.8	
Place of residence	Rural	80	16.9	
	Urban	393	83.1	
Father's age (in years)	30-40	172	36.4	44.68±6.92
	41-50	220	46.5	
	>50	81	17.1	
Father's education	No education	79	16.7	
	Primary	34	7.2	
	Secondary	165	34.9	
	Higher Secondary	98	20.7	
	Graduate and above	97	20.5	
Father's occupation	Job	153	32.3	
	Business	21	4.4	
	Farming	12	2.5	
	Teaching	138	29.2	
	Day labor	46	9.7	
	Others	103	21.8	
Mother's age (in years)	25-35	213	45.0	37.81±6.01
	36-45	209	44.2	
	> 45	51	10.8	
Mother's education	No education	82	17.3	
	Primary	92	19.5	
	Secondary	215	45.5	
	Higher Secondary	37	7.8	
	Graduate and above	47	9.9	
Mother's occupation	Housewife	432	91.3	
	Job	25	5.3	
	Others (including business)	16	3.4	
Monthly family income (in taka)	<10000	158	33.4	20718.71±2057.22
	10000-20000	184	38.9	
	20000-30000	67	14.2	
	30000-40000	25	5.3	
	>40000	39	8.2	

Note: 'n, number of children', 'SD, standard deviation'.

Table 2: Smartphone and health-related characteristics of the children, (N= 473)

Characteristics	Categories	<i>n</i>	%	mean±SD
Smartphone ownership	No	138	29.2	
	Yes	73	15.4	
	Family members have	262	55.4	
Mode of internet connection	No connection	215	45.5	
	Mobile data connection	174	36.8	
	Broadband connection	84	17.8	
Time spent (in hours) on smartphones (per day)	No use	198	41.9	1.81±2.44
	<1	63	13.3	
	1-3	91	19.2	
	3-5	78	16.5	
	>5	43	9.1	
Playing hours (per day in hours)	No playing	199	42.1	0.65±0.84
	0-1	161	34.0	
	1-2	86	18.2	
	2-3	20	4.2	
	>3	7	1.5	
Skipping breakfast	Never	171	36.2	
	Sometimes	302	63.8	
Headache due to smartphone use	No	269	56.9	
	Yes	204	43.1	
Do you feel anxiety	Not at all	256	54.1	
	Sometimes	217	45.9	
Little interest or pleasure in doing things	Not at all	150	31.7	
	Sometimes	323	68.3	
Feeling down, depressed, or hopeless?	Not at all	217	45.9	
	Sometimes	256	54.1	
Feeling tired or having little energy?	Not at all	232	49.0	
	Sometimes	241	51.0	
Poor appetite or overeating?	Not at all	232	49.0	
	Sometimes	241	51.0	
Feeling bad about yourself - or that you are a failure or have let yourself or your family down?	Not at all	331	70.0	
	Sometimes	142	30.0	
Trouble concentrating on things, such as reading the newspaper or watching television?	Not at all	279	59.0	
	Sometimes	194	41.0	
Thoughts that you would be better off dead, or of hurting yourself in some way?	Not at all	366	77.4	
	Some time	107	22.6	

Note: ‘*n*, number of children’, ‘SD, standard deviation’.

Table 3. Association between time spent on smartphone use and socio-demographic factors among secondary school children, ($N = 473$)

Characteristics	Categories	Time spent on smartphones		<i>p</i> -values
		Normal use (n_1) (≤ 2 hours) (%)	Excessive use (n_2) (>2 hours) (%)	
Age (in years)	13-14	44(69.8)	19(30.2)	0.039
	15-16	190(64.2)	106(35.8)	
	17-18	88(77.2)	26(22.8)	
Gender	Boys	143(75.3)	47(24.7)	0.006
	Girls	179(63.3)	104(36.7)	
Academic grade	VIII	89(58.9)	62(41.1)	0.008
	IX	77(68.8)	35(31.3)	
	X	156(74.3)	54(25.7)	
Type of family	Nuclear	255(71.0)	104(29.0)	0.014
	Extended	67(58.8)	47(41.2)	
Number of family members	2-4	158(69.9)	68(30.1)	0.129
	5-6	123(69.9)	53(30.1)	
	>6	41(57.7)	30(42.3)	
Number of siblings	1	54(73.0)	20(27.0)	0.301
	2	144(64.0)	81(36.0)	
	3	89(70.1)	38(29.9)	
	>3	35(74.5)	12(25.5)	
Birth order	1 st	169(67.9)	80(32.1)	0.744
	2 nd	96(66.2)	49(33.8)	
	3 rd	43(74.1)	15(25.9)	
	$\geq 4^{\text{th}}$	14(66.7)	7(33.3)	
Living with family	No	9(60.0)	6(40.0)	0.495
	yes	313(68.3)	145(31.7)	
Place of residence	Rural	58(72.5)	22(27.5)	0.352
	Urban	264(67.2)	129(32.8)	
Father's age (in years)	30-40	125(72.7)	47(27.3)	0.144
	41-50	148(67.3)	72(32.7)	
	>50	49(60.5)	32(39.5)	
Father's education	No education	69(87.3)	10(12.7)	0.000
	primary	27(79.4)	7(20.6)	
	secondary	104(63.0)	61(37.0)	
	Higher Secondary	72(73.5)	26(26.5)	
	Graduate and above	50(51.5)	47(48.5)	
Father's occupation	Job	100(65.4)	53(34.6)	0.012
	Business and farming	25(75.8)	8(24.2)	

	Teaching	103(74.6)	35(25.4)	
	Day labor	36(78.3)	1021.7	
	others	58(56.3)	45(43.7)	
Mother's age (in years)	25-35	157(73.7)	56(26.3)	0.031
	36-45	136(65.1)	73(34.9)	
	> 45	29(56.9)	22(43.1)	
Mother's education	No education	67(81.7)	15(18.3)	0.000
	Primary	65(70.7)	27(29.3)	
	Secondary	151(70.2)	64(29.8)	
	Higher Secondary	20(54.1)	17(45.9)	
	Graduate and above	19(40.4)	28(59.6)	
Mother's occupation	Housewife	299 (69.2)	133(30.8)	0.026
	Job	11(44.0)	14(56.0)	
	Others (including business)	12(75.0)	4(25.0)	
Monthly family income (in taka)	<10000	122(77.2)	36(22.8)	0.000
	10000-20000	131(71.2)	53(28.8)	
	20000-30000	38(56.7)	29(43.3)	
	30000-40000	11(44.0)	14(56.0)	
	>40000	20(51.3)	19(48.7)	
Total		322(68.1)	151(31.9)	

Table 4. Association between time spent on smartphones and smartphone- and health-related factors among secondary school children, ($N = 473$)

Characteristics	Categories	Smartphone use time		<i>p</i> -values
		Normal use (<=2 hours) (%)	Excessive use (>2 hours) (%)	
Smartphone ownership	No	132 (95.7)	6(4.3)	0.000
	Personal or family members	190(56.7)	145(43.3)	
Mode of internet connections	No connection	178(82.8)	37(17.2)	0.000
	Mobile data connection	102(58.6)	72(41.4)	
	Broadband connection	42(50.0)	42(50.0)	
Skipping breakfast	Not at all	121(70.8)	50(29.2)	0.346
	Sometimes	201(66.6)	101(33.4)	

Playing hours (per day)	No	158(79.4)	41(20.6)	0.000
	Yes	164(59.9)	110(40.1)	
Headache due to smartphone use	No	50.0%	50.0%	0.047
	Yes	129(63.2)	75(36.8)	
Feeling anxiety	Not at all	193(75.4)	63(24.6)	0.000
	Sometimes	129(59.4)	88(40.6)	
Sleeping quality	Not good	13(54.2)	11(45.8)	0.134
	Good	309(68.8)	140(31.2)	
Little interest or pleasure in doing things	Not at all	114(76.0)	36(24.0)	0.012
	Sometimes	208(64.4)	115(35.6)	
Feeling down, depressed, or hopeless	Not at all	166(76.5)	51(23.5)	0.000
	Sometimes	156(60.9)	100(39.1)	
Feeling tired or having little energy	Not at all	175(75.4)	57(24.6)	0.001
	Sometimes	147(61.0)	94(39.0)	
Poor appetite or overeating	Not at all	163(70.3)	69(29.7)	0.184
	Sometimes	159(66.0)	82(34.0)	
Feeling bad about yourself - or that you are a failure or have let yourself or your family down	Not at all	247(74.6)	84(25.4)	0.000
	Sometimes	75(52.8)	67(47.2)	
Trouble concentrating on things, such as reading the newspaper or watching television	Not at all	199(71.3)	80(28.7)	0.069
	Sometimes	123(63.4)	71(36.6)	
Thoughts that you would be better off dead, or of hurting yourself in some way	Not at all	272(74.3)	94(25.7)	0.000
	Some time	50(46.7)	57(53.3)	
Total		322(68.1)	151(31.9)	

Table 5. Determination of risk factors using binary logistic regression model for smartphone use time in Rajshahi City, Bangladesh

Characteristics	Coefficient (β)	Unadjusted OR (95% CI)	p-values	Coefficient (β)	Adjusted OR (95% CI)	p-values
Smartphone use time Normal use (r) Excessive use	Headache due to smartphone use (No versus Yes)					
	--	1		--	1	
	0.390	1.476 (1.00-2.179)	0.050	0.354	1.425(0.913-2.224)	0.119
Smartphone use time Normal use (r) Excessive use	Feeling anxiety (Not at all Vs. sometimes)					
	--	1		--	1	
	0.737	2.090(1.411-3.095)	0.000	0.620	1.859(1.207-2.863)	0.005
Smartphone use time Normal use (r) Excessive use	Little interest or pleasure in doing things (Not at all Vs. sometimes)					
	--	1		--	1	
	0.560	1.751(1.129-2.714)	0.012	0.597	1.816(1.127-2.927)	0.014
Smartphone use time Normal use (r) Excessive use	Feeling down, depressed, or hopeless (Not at all Vs. sometimes)					
	--	1		--	1	
	0.735	2.086(1.396-3.11)	0.000	0.569	1.767(1.142-2.734)	0.011
Smartphone use time Normal use (r) Excessive use	Feeling tired or having little energy (Not at all Vs. sometimes)					
	--	1		--	1	
	0.675	1.963 (1.322-2.91)	0.001	0.603	1.827(1.189-2.808)	0.006
Smartphone use time Normal use (r) Excessive use	Feeling bad about yourself - or that you are a failure or have let yourself or your family down (Not at all Vs. sometimes)					
	--	1		--	1	
	0.966	2.627(1.74-3.967)	.000	0.844	2.326(1.488-3.636)	0.000
Smartphone use time Normal use (r) Excessive use	Trouble concentrating on things, such as reading the newspaper or watching television (Not at all Vs. sometimes)					
	--	1		--	1	
	0.362	1.436(.971-2.122)	0.070	0.461	1.586(1.035-2.430)	0.034
Smartphone use time Normal use (r) Excessive use	Thoughts that you would be better off dead, or of hurting yourself in some way (Not at all Vs. sometimes)					
	--	1		--	1	
	1.194	3.299(2.111-5.154)	0.000	1.093	2.983(1.823-4.880)	0.000

Notes: ‘r, Reference category’, ‘CI, Confidence interval’, ‘OR, Odds ratio’

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**Agricultural production systems and livelihoods as affected by climate
change at some selected villages of coastal region of Bangladesh and
adaptation measures**

By

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Year: 2022

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Acronym and Abbreviation

ADB	Asian Development
BARI	Bangladesh Agricultural Research Institute
BARC	Bangladesh Agricultural Research Council
BRRI	Bangladesh Rice Research Institute
BINA	Bangladesh Institute of Nuclear Agriculture
BBS	Bangladesh Bureau of Statistics
BDT	Bangladesh Taka (Bangladesh Currency)
BRAC	Bangladesh Rural Advancement Committee
CIMMYT	International Maize and Wheat Improvement Center
CCAF	Climate Change, Agriculture and Food Security of CGIAR
CGIAR	Consultative Group in International Agricultural Research
DAE	Department of Agricultural Extension
DoF	Department of Fisheries
ha	Hectare (area-10,000 m ² or 2.47 Acres)
HYV	High Yielding Varieties
IPM	Integrated Pest Management
IRRI	International Rice Research Institute
NGO	Non-Government Organization
SRDI	Soil Resource and Development Institute
T.aman	Transplanted Aman Rice
T.aus	Transplanted Aus Rice
WB	World Bank
WLE	Water, Land and Ecosystems Program of

Glossary

Bagda: Brackish water shrimp species

Boro rice: Transplanted rice grown in Rabi and Khaif-I season with frequent irrigation

Beel: Natural depression of land. Perennial water body in the floodplain

Bigha: One third of an acre or 1320m².widely used in Bangladesh

Char: Newly accreted land from river/sea bed

District: Administrative unit comprising several Upazilas

Golda: Freshwater shrimp species

Gher: Is a Bengali word means surrounded by something. Here Gher means excavated water body surrounded all sides by 1-2 meter height of polder made by soils mainly for shrimp culture, along with other fish and T.aman rice cultivation. In some Gher Boro rice is also cultivated. It is linked with nearby river/canal for entering of saline tidal water. That is water entrance and drainage is controlled by sluice gate. Within Gher there is small long canal in all sides where water remains and shrimp and fishes take their shelter. On the bank of 1–2 meter wide Gher often vegetables are cultivated; also creeping vegetables are grown on trellis made on the water body by fixing bamboo.

Kharif-I: Monsoon crop growing season: 16 March to 15 July

Kharif-II: Crop growing season: 16 July to 15 October

Haor: Natural land depression having 1–2-meter natural water in monsoon but in Rabi season water recedes when single Boro rice is grown, mostly situated in north-east Bangladesh

Polder: Reclaimed land with water management system

Rabi: Winter crop growing season: 16 October to 15 March

Rainfed: Crop grown depending on natural rain or on stored soil moisture

Sunderbans: Name of world largest mangrove forest in southwest Bangladesh

Shail rice: Local cultivars of aman rice grown during monsoon having good taste

Taka: Bangladesh currency

T. aus: Rice grown in Kharif-I season generally with irrigation

T.aman: Rice grown in Kharif-II season generally with natural rainfall but often supplementary irrigation is applied in case of drought

Upazila: Administrative unit under a district comprising several unions

Agricultural production systems and livelihoods as affected by climate change at some selected villages of coastal region of Bangladesh and adaptation measures.

1. Executive Summary

The devastating effect of climate change is largely modifying the ecosystem, farming practices, farmer's income and overall livelihoods of Bangladesh people particularly crucial for southern coastal region where 40 million people lives near the coast mostly dependent on agriculture and fisheries. A study was conducted to find out how climate change is affecting the agricultural production systems and people's livelihood of selected coastal region villages and to suggest possible adaptation measures/strategy. In this context farmer's perception about climate change, climatic variation, soil salinity, tidal water effect, other bio-physical factors and adaptation measures against the changing environments were captured. Six FGD was conducted in different villages of Jhalokati, Pirojpur, Bagerhat and Satkhira district of Bangladesh where climate change effect is more critical. Available climatic and soil salinity data was collected from concerned organizations for evaluation. For collating agricultural adaptation options different agricultural research organization scientists was contacted along with communities' own experience and innovation. Community members (both men and women) believe that climate is continuously changing, creating unbearable heat wave round the year except in short winter period, rainfall is erratic and often excessive rainfall in a day/week, more cyclonic storm, higher tidal water pressure and increased water height in rivers, canal, increased soil and water salinity which causing loss of lives, crops, cultured fish, trees, livestock, houses and other properties. Farmers also reported very limited natural fish availability, increased pest and diseases of crops and diversified health hazards for human. Farmers suggested for uplifted and stronger polder to save crop land and household from tidal saline water and for protection from cyclonic surge. Moreover, for reducing the increasing salinity level in dry season water flow of trans-boundary river, Ganga-Padma-Gorai-Modhumati must be increased through ensuring due share of Ganges water from India.

Long term climatic data revealed that there was no trend in rainfall over the years but variability among the year is prominent. South central Patuakhali has more average rainfall having six months >200 mm rainfall (May-October) while November to March is mostly dry period. While for Mongla (Bagerhat) > 200 mm rainfall is for 4 months (June-September) and dry months are five (Nov-March). For Satkhira the far south-west of Bangladesh >200 mm rainfall is only for four months (June-Sept) and dry period is maximum six months (Nov-April). Thus, rainfall gradually decreased from south eastern part to south western part. There was also no trend in maximum or minimum temperature but April-May was the hottest months and Nov-March is suitable for growing high value rabi crops along with boro rice planting in late January. Cultivable lands are becoming more saline over the years associated with high degree of salinity where crop growth is limited. In rabi season most of the land still remains fallow following T. aman rice for different reasons, though there is agronomic potentiality to grow high value crops in this season.

Farmers and businessmen have developed different innovative measures to cope with the changing environment, water level and salinity. Some are good without damaging ecosystems and food security such as mixed Gher where fish, shrimp, rice and vegetable is grown at a time but brackish water shrimp Gher is badly damaging the whole ecosystems rendering the small and marginal farmers poorer and diseased, losing all other livelihood options mostly promoted by outsider big businessmen. Researchers of different research institutions have developed good number of saline and heat tolerant cultivars of different crops including boro rice (winter rice), wheat, homestead vegetable model, tower system of vegetable production and dozens of other crops and agronomic techniques which minimize the effect of salinity, water logging and water stress. Ring slab set in tidally flooded crop field saves the brooding fish and fish fry from extinction. For adaptation and dissemination of climate smart agriculture recommendation has been suggested for selecting climate smart villages in coastal region. However, many developed technologies are location specific due to variation in tidal water intrusion, salinity

level, polder, topography, soil quality, seasonal climatic variation and farmer's/businessmen management, available resource, food habit and market demand; thus, need in-depth community-based research and development work for adapting with ever changing coastal environments and ecosystems.

2. Background and Rationale

Climate change and climatic variations have a profound effect on agriculture and livelihoods of rural communities of Bangladesh. The impacts of climate change are likely to result in huge economic, social, and environmental damage to South Asian countries, compromising their growth potential and poverty reduction efforts (ADB, 2014). Agriculture in Bangladesh has progressed in recent years, allowing a large number of people to be fed from relatively small areas. However, Bangladesh agriculture is extremely vulnerable to climate change and it has increased the possibility of more cyclonic storm due to global temperature increase and other allied factors. The studied area faced 14 cyclones (big or small) during 1970-2022 costing thousands of humans and livestock life and devastated the livelihoods of millions including agriculture, aquaculture, livestock, forest, houses, communications, polders, sweet water sources including drinking water and other infrastructures (BBS, 2021). Economic loss due to Super cyclone Sidr was 1.7 billion USD and 6.7 million people were affected while cyclone Aila caused a loss of 269.28 million USD and 3.9 million people were affected (World Bank, 2010). Moreover, higher temperatures eventually reduce yields of desirable crops while encouraging weed and pest proliferation. Changes in precipitation pattern (timing and amount) increase the likelihood of short-run crop failures and long-run production declines, posing a serious threat to food security. Although there will be gain in some crops in some regions, the overall impacts of climate change on agriculture are expected to be negative and need to be much better understood.

Bangladesh occupies a unique geographic location spanning a relatively short stretch of land between the mighty Himalayan Mountain chain and the open ocean. It is virtually the only drainage outlet for a vast river basin complex made up of the Ganges, Brahmaputra and Meghna rivers and their network of tributaries. These rivers, which cause almost regular and serious floods over much of the country during the summer monsoons, are reduced seriously during the dry winter months (NAP, 2006). Bangladesh has a total land surface of 12.31 million hectares, of which presently 7.85 million hectares are under agriculture (NAP, 2006). About 30 % area of Bangladesh belongs to coastal area, which is regularly and recurrently battered by calamities like, cyclone, tidal bore/surge, inundation, intrusion of saline water etc. costing thousands of lives and huge number of properties (Amin *et al.*, 2008). Three indicators have been considered for determining the landward boundaries of the coastal zone of Bangladesh. These are influence of tidal waters, salinity intrusion and cyclones/storm surges (CZPo, 2005). Nineteen districts near the coastal boundary of the country are being affected directly or indirectly by some of these phenomena. In Bangladesh, salinization is one of the major natural hazards hampering crop production. About 53% of coastal area is affected by different degrees of salinity (Islam, 2004). According to BARC (1998), light 0.29, moderate 0.43 and high 0.12 million hectares land salinization was observed in Bangladesh which cost 586.75 million USD per year (NAP, 2006). The Global Climate Risk Index (CRI) for 2021, places Bangladesh seventh among ten countries that bore the cumulative impact of climate change between 2000 and 2019. During this time Bangladesh experienced extreme weather events that cost the country a combined loss of \$3.72 billion estimated by Germanwatch (<http://www.germanwatch.org/en/cri>). Additionally, salinity affected soil increased 21% in last three decades in this region (Salaudhin and Ashikuzzaman, 2012). Future changes of temperature and rainfall are estimated for Bangladesh and it was found from the observed data that the temperature is generally increasing in the monsoon season (June-August) (IPCC, 2007). Salinity increased over the years mainly due to three reasons, viz. i) drastic deduction of sweet water flow from upstream in dry season, i.e. from the Padma (Ganges) and its tributaries, because of water diversion by India through Farakka barrage,

ii) breaching of embankment by recurrent tidal surge/cyclone, iii) Secondary salinity: it is the artificial intrusion of saline water for shrimp cultivation by big fisherman cum trader in the cultivable land, popularly called “Gher” (Ali et al., 2014). This situation is changing the biodiversity of the vast area including crops and cropping patterns, trees, grasses etc., rendering a devastating impact on health, livelihoods, and income of the farmers. The resource poor farmers and fishermen are affected the most. Thus, coping with the changing climate is important through modern technology, crops/trees/varieties/cropping systems/farming systems, land management, water management, effective early warning systems against cyclone, temporary safe shelter, better design of dwelling house, for the overall livelihoods improvements of farming community, particularly for the resource-poor. The coastal zone covers 19 out of 64 districts facing or in proximity to, the Bay of Bengal, encompassing 153 Upazilas (MoWR, 2006). Out of these 19 districts, only 12 districts directly meet the sea or lower estuary. A total of 48 Upazilas of these districts are considered as ‘exposed’ directly to vulnerabilities from natural disasters (CZPo, 2005).

IPCC (2001) define adaptation as adjustment in ecological, social or economic systems in response to actual or expected climatic stimuli and their effects or impacts. This term refers to changes in processes, practices, or structures to moderate or offset potential damages or to take advantage of opportunities associated with changes in climate. It involves adjustments to reduce the vulnerability of communities, regions, or activities to climatic change and variability (Lisa, 2007). In this context present study has been undertaken to characterize the climatic variability, bio-physical and socio-agro-climatic situation of the selected coastal villages of Bangladesh at household level and to identify the potential adaptation measures for the farming community of these areas against climate change and climatic variation.

3. Methodology

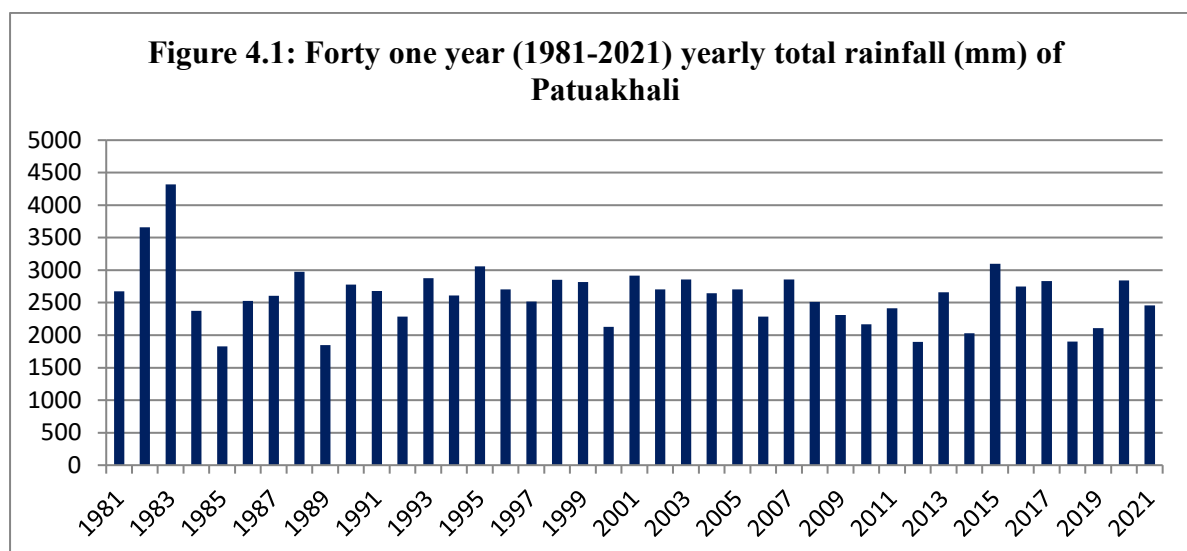
The study was undertaken in four coastal districts of Bangladesh viz. Jhalokathi, Pirojpur, Bagerhat and Satkhira having one village each for Jhalokathi(Gaula) and Bagerhat(Sripur); and two villages each for Pirojpur(Biraljuri, Ruhitalbunia) and Satkhira(Chadipur, Buri Golalini). In total six focal group discussions were done in six villages participated by 150 persons (54 female and 96 male farmers). FGD was conducted against an open-ended details checklist/questionnaire. In each FGD 14-40 men and women farmers participated. Besides this we met a large number of stakeholders of the regions including agricultural scientists, extension workers/officials, officers of Fisheries department, NGO workers, local administration including Upazila Chairman, Vice-Chairman, farmers, businessmen, policymakers and investors. Moreover, environmental, soil salinity, agriculture, fisheries related data was collected from concerned departments for natural resource base mapping. Extensive field visit was done to assess the socio-agro-economic and environmental conditions of each area. Long term environmental data was collected from Bangladesh Meteorological Department (BMD). When environmental data of one location was not available, the data of nearby station was considered. Jalokathi and Pirojpur have no environmental station, so we considered data of nearby Patuakhali BMD station. Detailed desktop browsing was done to collect related literatures. Also, relevant book, journal articles, research report was collected to analyze the situation, collate the adaptation measures against climatic variation/climate change. Extensive peer group field visit was organized to observe the effect of climate change and farmer’s adaptation measures against the changing scenarios. Moreover, through personal communication with scientists and innovators potential adaptation options were recorded.

4. Results and Discussion

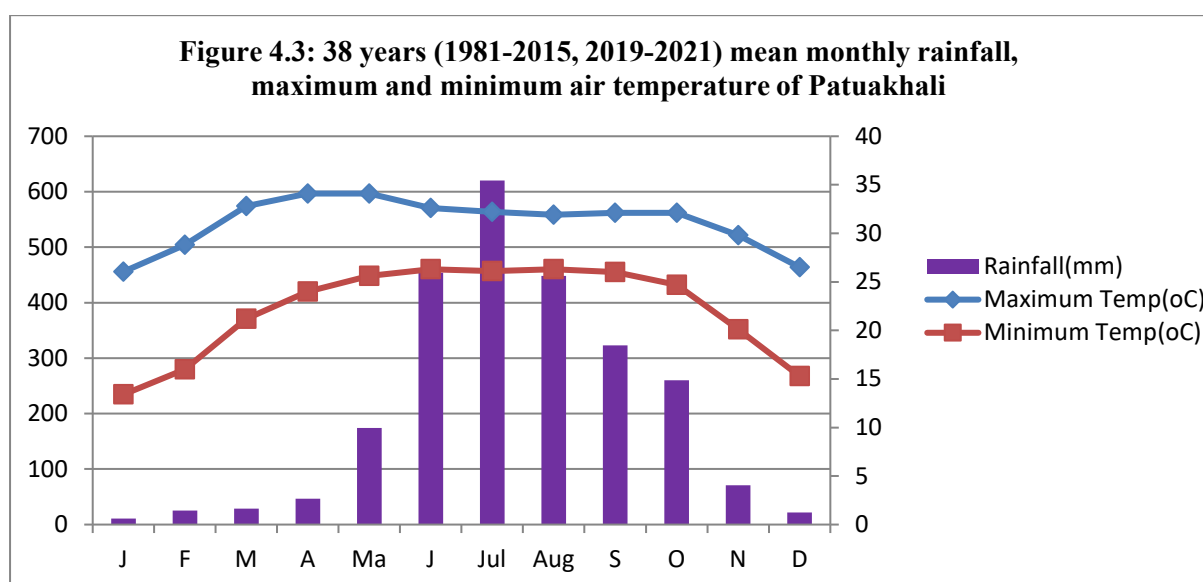
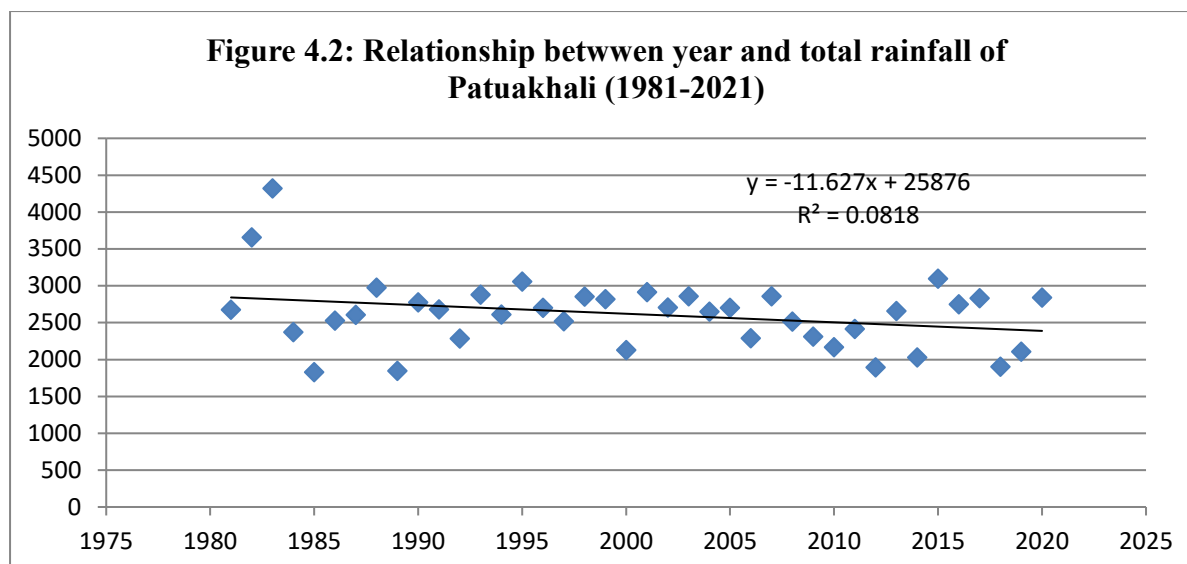
4.1. Rainfall and temperature variations

Climatic variability refers to variations in the mean state and other climatic statistics (average deviation, the occurrence of extreme etc.) on all temporal and spatial scales beyond those of individual weather

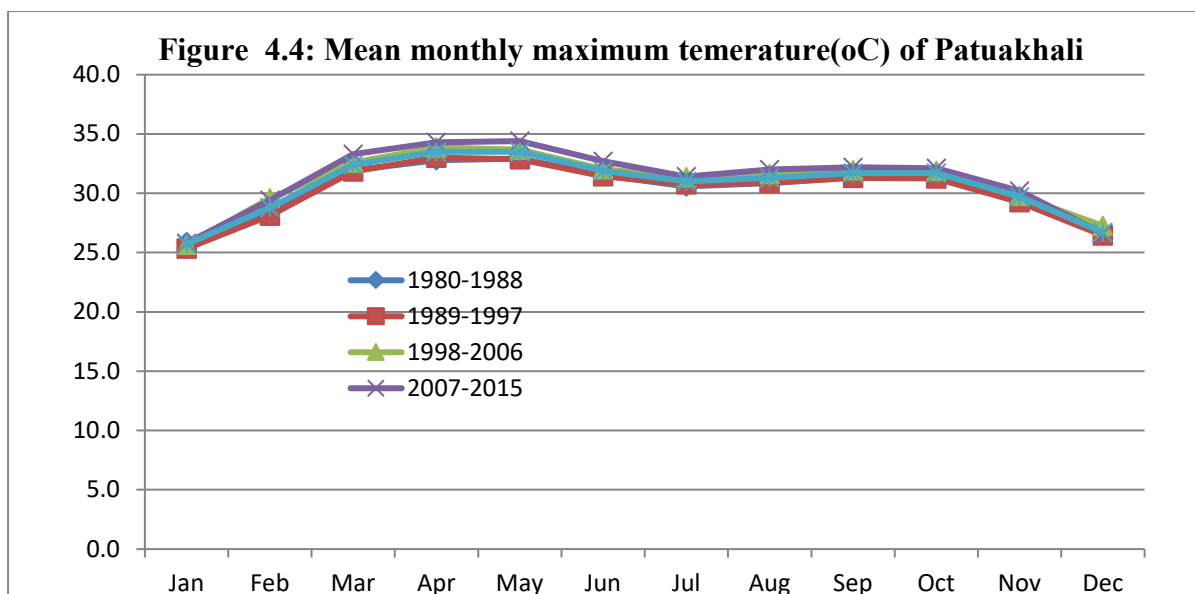
events. Variability may result from natural internal processes within the climate system (internal variability) or from variations in natural or anthropogenic external forces (external variability). Each year in a specific time period, the climate of a location is different. Some years have below average rainfall, some have average, or above average rainfall. For example, average annual rainfall of Patuakhali is 2611 mm (Average mean deviation 332 mm). We are not assured of getting this amount every year. The actual rainfall varying from the mean may represent drought or flood conditions.



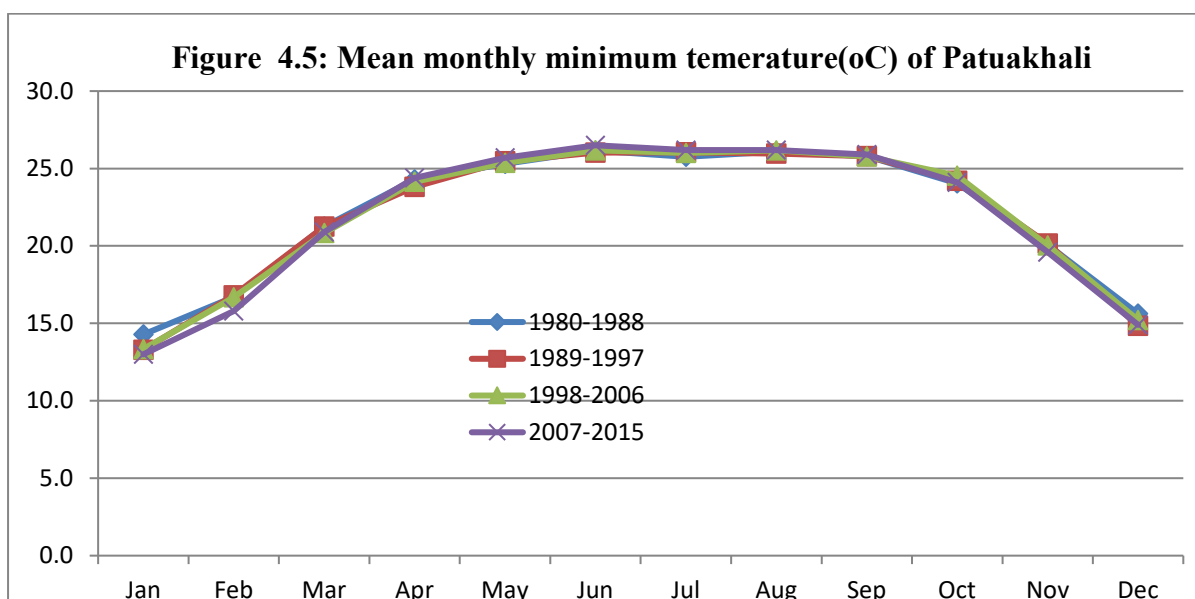
Actually, no clear-cut trend is found within 41 years rainfall data though it was high in 1982 and 1983 but in later years it was almost in similar fashion with average deviation of 332 mm (Fig 1). There is no clear-cut relationship between year and amount of rainfall, though indication is that rainfall is gradually decreasing in small amount (Fig 2) at Patuakhali. The monthly average rainfall data indicates (Fig 3) that 06 months got >200 rainfall (May to October) and dry spell is for 05 months (Nov-March). However, the tidally flooded coastal belt of Bangladesh is also blessed with tidal water from April-15 to October. So, the area doesn't depends on only rainfall but tidal water and seasonal storm modify the water situations of the ecosystems thus often T.aman rice planting is delayed up to end of August for receding of tidal and rain water so that seedling height is appropriate to cope with daily tide. All the high value rabi season crops such as maize, wheat, vegetables, water melon, sunflower, moonbeam etc. grows in dry period when rainfall is either absent or scanty, so to cope with the evapotranspiration demand irrigation is needed. Stored soil moisture is not sufficient to get higher and economic yield of the crop. Thus irrigation from surface water source is crucial for this area to change the traditional one monsoon crop-T.aman. South central Bangladesh including Barisal, Patuakhali, Jhalokati and Pirojpur region river/canal tidal water is mostly non-saline (Ali, 2014: SRDI, 2010) which could be uplifted for irrigation. However, local farmers still keep the land fallow after T.man rice and small number of famers cultivates rabi crops with supplemental irrigation. But all those high value rabi crops requires only 2-3 irrigation (except water melon) where boro rice requires 20-25 flood irrigations. So, the area has potentiality to grow rabi season crops with irrigation (Ali, 2014) with a small additional cost. And for irrigation if axial flow pump is used cost of irrigation is 40 % less than traditional centrifugal pump (CIMMYT, Shah-Al-Emran Personal communication; Ali, 2014). However, for getting the proper planting time and temperature regimes short duration aman rice such as BINA Dhan 7, BRRI Dhan39 could be planted in suitable lands in a community approach.



Thirty-five years maximum average maximum temperature data analysis revealed that (Fig 4) it has increased up to 0.8°C in April and 0.9°C in May in 2007-2015 periods in comparison to 1989-1997 periods. Increase of temperature in other months is not visible. It proves the farmer's perception that heat wave is unbearable during the month of April and May (Table 2). The temperature is unbearable more due to high humidity. Mondal et al. (2012) reported that humidity has increasing trends of 1.0%, 0.4% and 1.1% per decade in the premonsoon, post-monsoon and winter seasons, respectively, and decreasing trend of 0.2% in the monsoon season. Excessive humidity also has a negative effect on seed storage and instigates fungal diseases to crops.



However, no such increasing trend of temperature is found for mean minimum temperature of different periods (Fig 5). The data indicates that winter crops (called rabi crops in Bangladesh) including wheat, lentil, chickpea, field pea, grass pea, onion, garlic, carrot, soybean, mustard, sunflower, potato, winter hybrid maize, all winter vegetables could be grown within November to March as minimum temperature range is within 13.5-21.1°C. However, for achieving maximum yield potentiality November and early December is the ideal time for crop establishment. Moreover, the day and night temperature of February and March suddenly rises above the mean level which causes forced maturity of legumes and wheat resulting in un-shriveled grain and poor yield. Thus, early planting is environmentally safer. In late planting situation tidal water destroy the crop in Mid-April associated with cyclone. Oppositely early boro rice planting would be avoided to escape from cold injury of January which causes grain sterility due to fertilization problem. As maximum cold period of the year is from late December to mid- January which delay the germination and growth of majority crops. For fish culture also December-January should be avoided as low temperature retard consumption of feed by fish for low metabolic activities causing poor/no growth of fish.



Mongla weather data analysis (Fig 4.6) revealed that average annual rainfall is 1942 mm and average mean deviation is 240 mm. Compared to other studied location Mongla (but only 14 years) rainfall has slightly increased trend (Fig 4.7), however relationship between year and rainfall is not significant. Four months (June-September) has >200 mm rainfall and dry month periods are 6 (Nov-April) while May and October have also fairly good rainfall (170 mm or more) over the years (Fig 8). But as a tidal area here also natural tidal water enters the crop field around 15 April, which also dictates the moisture and flooding situation of the land. And water of the river and canals are almost non-saline or slightly saline which doesn't hamper crop germination or growth. Farmers choose June to September for T.aman seedling raising and transplanting for getting the benefit of rain water. So, compared to eastern district Patuakahi, Bagerhat has 669 mm less rainfall and two months less >200 mm rainfall period. It indicates wide variation in rainfall within a small geographical distance and rainfall is decreasing towards south-western Bangladesh.

Figure 4.6: Forteen years (2008-21) total rainfall (mm) of Mongla, Bagerhat

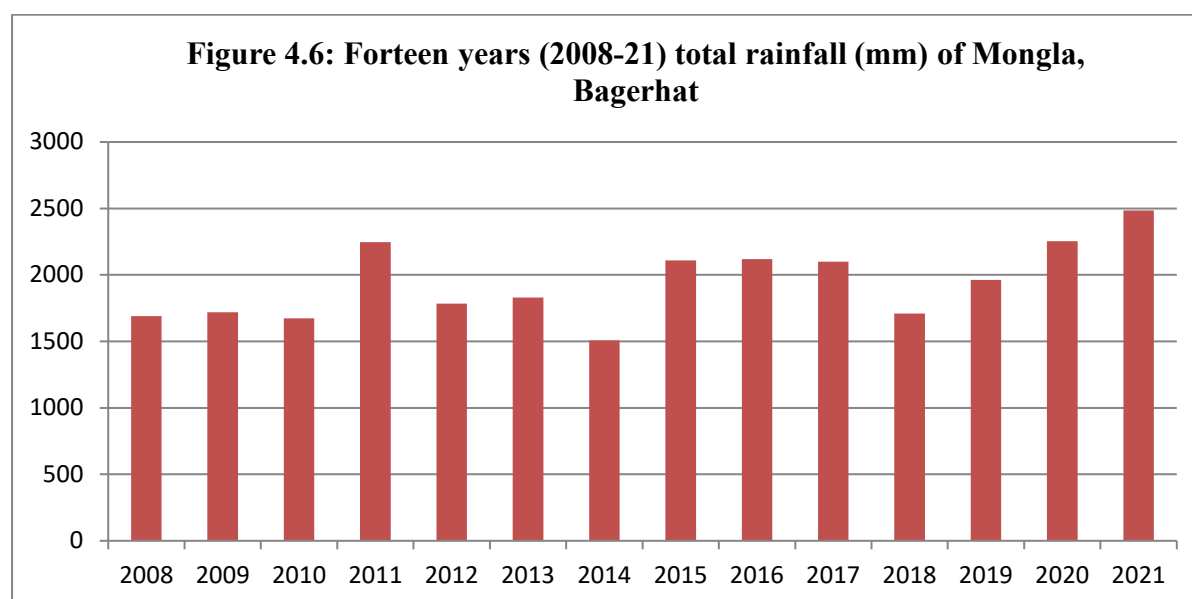
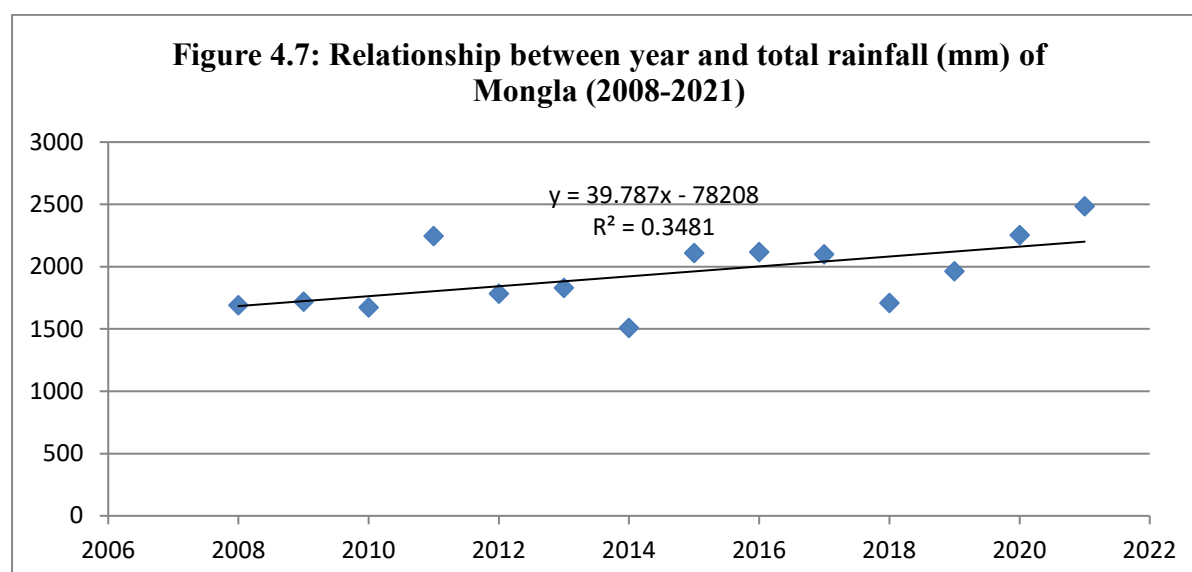
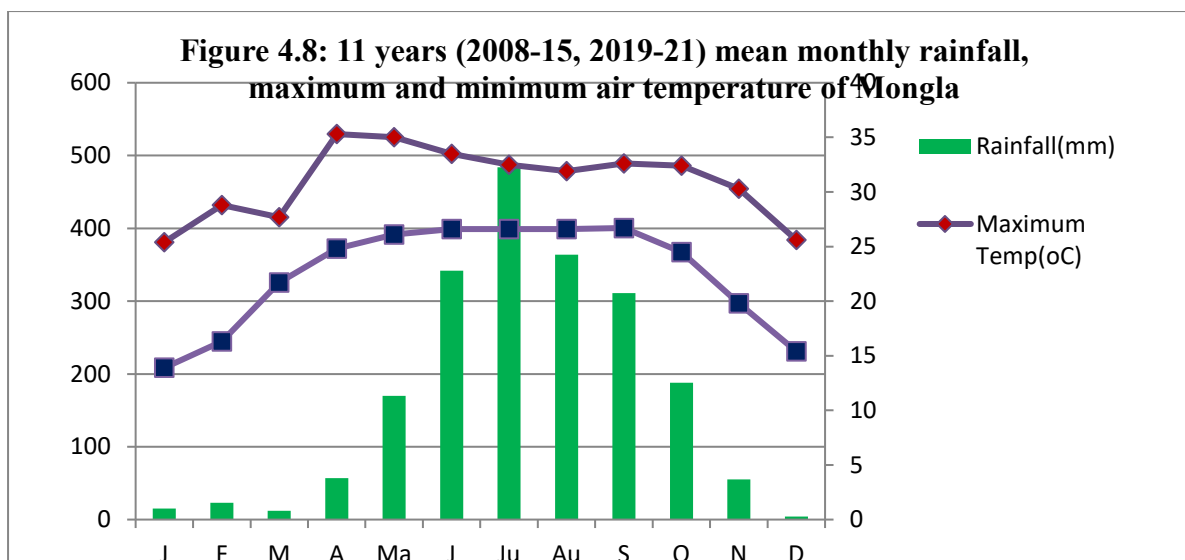
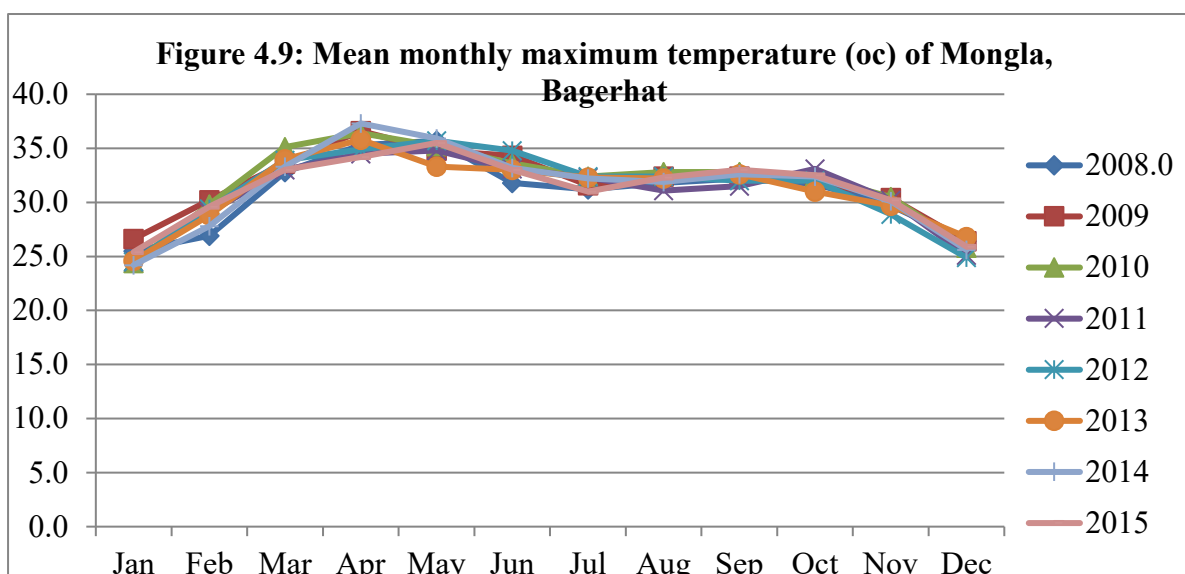


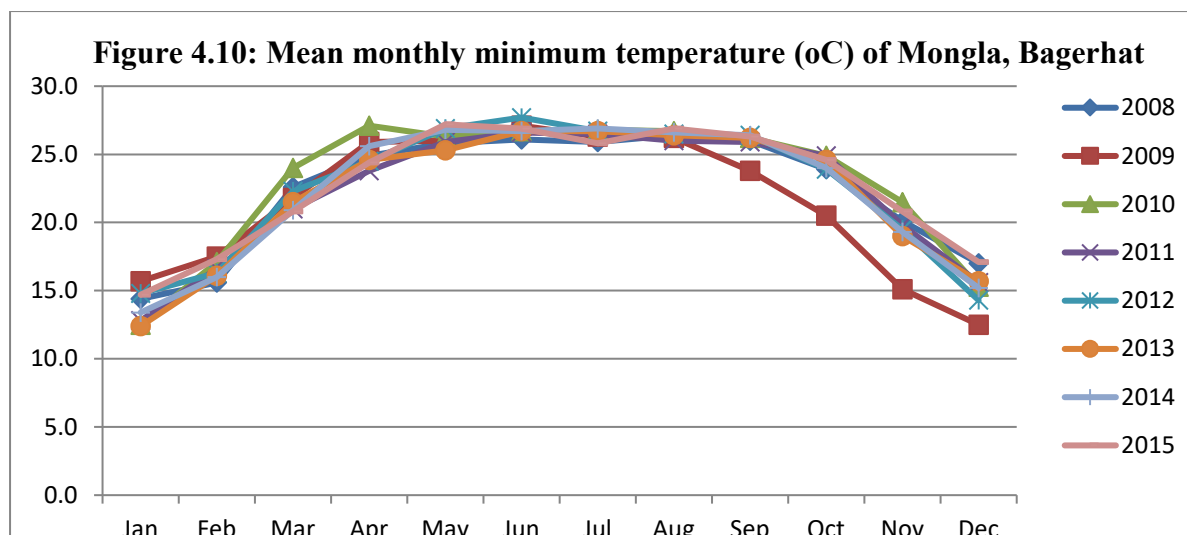
Figure 4.7: Relationship between year and total rainfall (mm) of Mongla (2008-2021)





Mongla temperature data analysis (Figure 9 and Figure 10) indicates no trend in increase or decrease of maximum and minimum air temperatures, rather yearly variation is visible. November to March is suitable for growing rabi crops and also boro rice in late January to get higher yield for getting maximum solar radiation. However, often excessive soil moisture and untimely tidal water dictates late planting of rabi season crops, as because drainage channel of crop field is either silted or encroached by human intervention.





Satkhira rainfall data analysis (42 years) showed that there is no trend over the years, the yearly variation may be up 900 mm. Average rainfall is 1719 mm and average deviation from mean is 219 mm (Fig 11, Fig 12)). The month which received >200 mm rainfall is 4 (June-September) and dry period is 6 months (November to April), while May and October received more than 100 mm precipitation. Figure 13 indicates that there is no significant relationship between year and amount of rainfall, but rainfall is slightly decreasing. Rainfall variability of Satkhira is more than Patuakhali and Bagerhat, as the area is far south-west of Bangladesh, where rainfall gradually decreased and it received the lowest average rainfall. Like other location it also received a good rainfall in May and October. Month of May rainfall helps to prepare land for seedbed and tilling of rice land while October rainfall helps panicle initiation of T.aman rice. May month precipitation helps to release fish fry to pond and other water bodies while October rain helps to maintain water at pond to continue growth of fish. For kharif vegetable May rainfall is crucial for growth and development while October precipitation is important to sow the seeds of potato and early season high value vegetables. Temperature data analysis (Fig 14, Fig 15) revealed that May is the hottest month (>35°C) along with April while January is the coldest month close to December. Like rainfall, temperature data also suggests no trend or increase of temperature rather yearly variation is obtained. Dry period is 6 months (Nov-April) when irrigation is most needed for boro rice, vegetable, maize, wheat and other vegetable crops. However, like other coastal tidal area here also tidal water enters the crop field around April 15. But tidal water of Satkhira is often saline affected except during pick monsoon, so generally not suitable for irrigation or crop growth. The area is mostly protected by polder to save from saline water but breaching of polder happens due to breaching of polder during big cyclone or tidal surge and sometimes due to forced intrusion of saline water by brackish water shrimp businessmen.

Figure 4.11: Forty two years(1980-2021) annual total rainfall (mm) of Satkhira

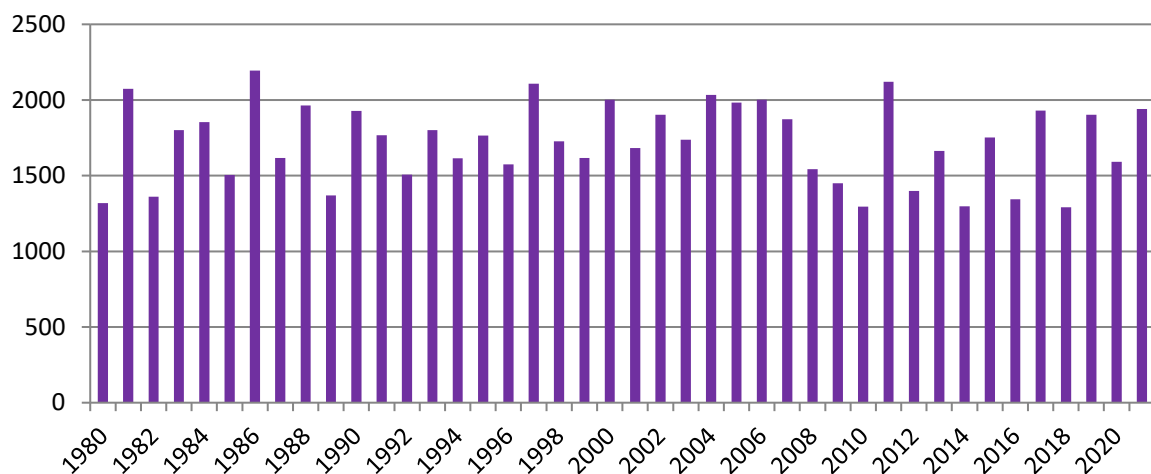


Figure 4.12: Mean monthly rainfall (36 yrs), maximum and minimum (8 yrs)

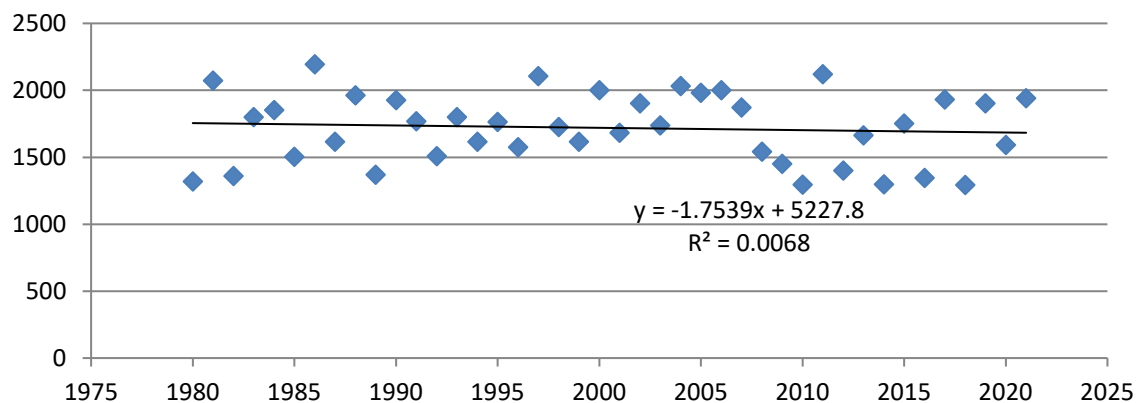
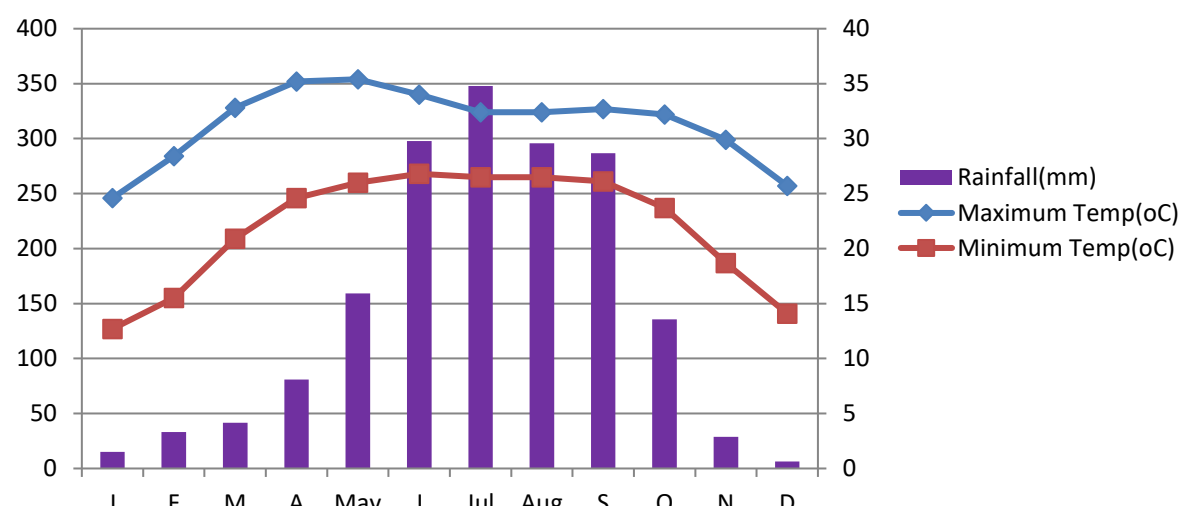
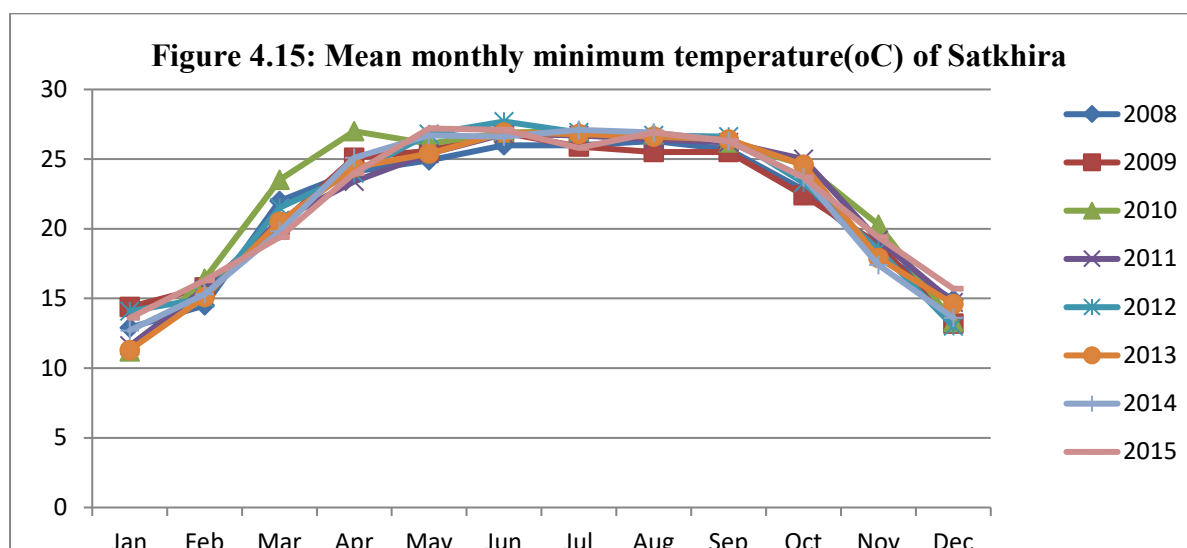
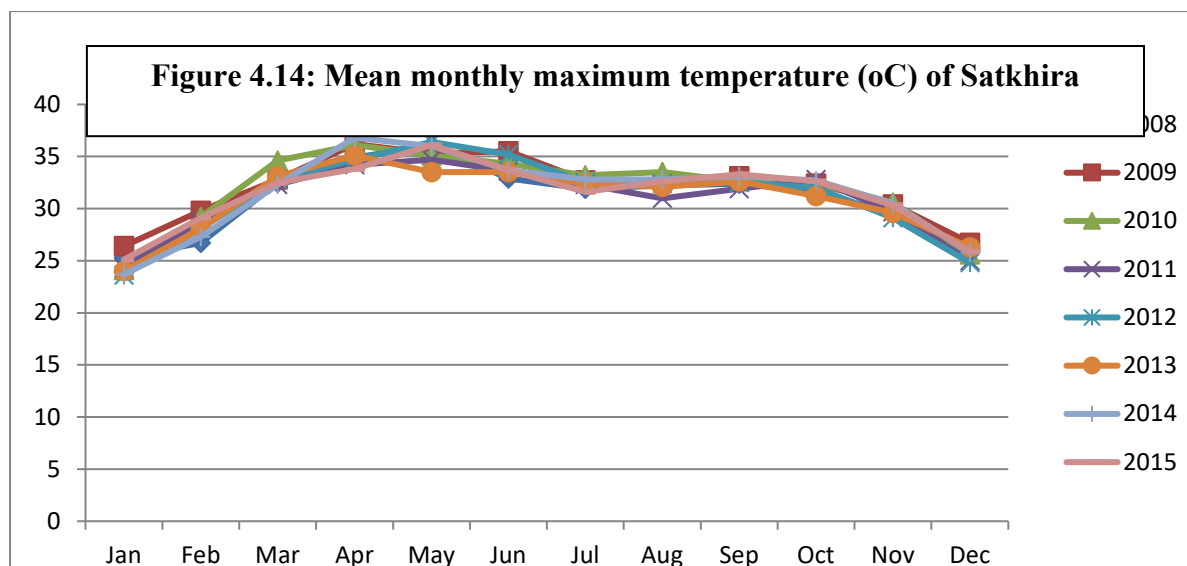


Figure 4.13: Relationship between year and total rainfall (mm) of Satkhira (1980-2021)



It would be worthwhile to mention that all climate change prediction model indicates that Bangladesh has to face sea level rise, high temperature and more rainfall in monsoon and low rainfall in winter which could largely modify the agricultural production scenario (Table1) in future.

Table 4.1: Climate change scenarios for Bangladesh by 2030 and 2050 (World Bank, 2000)

Year	Sea level rise (cm)	Season	Temperature increase (°C)	Precipitation fluctuation compared to 1990	Changes in evaporation (%)
2030	30	Monsoon	+0.7	+11	+15.8
		winter	+1.3	-3	-0.9
2050	50	Monsoon	+1.1	+28	+16.7
		winter	+1.8	-37	0

However, other model predicts more increase of temperatures. The projected temperature changes for the three periods are: 2030, 0.9°C–1.9°C; 2050, 1.6°C–2.5°C; and 2080, 2.9°C–4.2°C. The ensemble mean4 of temperature projections for all the Coupled Model Inter-comparison Project Phase 3 (CMIP3)

GCMs is around 3.0°C–3.5°C by the end of the 21st century. The high degree of agreement across the GCMs makes the increasing temperature trend a very confident estimate (ADB, 2014). Mondal et al. 2012 reported that the analysis of measured temperature (1948-2010) at 34 locations of Bangladesh indicates that the overall trend in all-Bangladesh annual temperatures is rising at a rate of about 1.2 oC per century. More importantly, this trend has become stronger in recent years. The trend in recent mean annual temperatures (1980-2010) is almost the double (2.4 oC per century) of the longer-term trend. The PRECIS (Providing Regional Climates for Impact Studies) projected future temperature has even a much higher trend (4.6oC per century). The rise in mean annual temperatures projected by IPCC (2007) for South Asia is 3.3 oC with a range of 2.0-4.7 oC.

The effect of temperature on agriculture is complex due to a number of interplaying factors. However, while higher carbon dioxide levels and solar radiation theoretically can increase food production, heat stress, shorter growing seasons, and higher evapotranspiration resulting in soil moisture levels being lowered counteract the former influences, leading to overall lower production of most foodstuffs, including most varieties of rice, wheat, and potato. Reductions in production could potentially be as high as a 17%–28% for rice and 31%–68% for wheat (Karim et al. 1999). The simulations carried out with the crop growth model (DSSAT) using PRECIS projected and bias corrected climatic data, analyzed soil quality data, field information on cultivation practices, field measurements, etc., indicate that the wheat production in Bangladesh would be highly vulnerable to climate change. The wheat yield may decrease by 26% on an average by the end of this century due to the projected warming and darkening. Among the two irrigated rice crops, the boro rice may be more vulnerable to climate change than the aman rice. The average yield of boro rice may reduce by 12%. The effect on aman rice may be mixed – the yield may decrease in a medium term (2050) and remain unchanged in a longer term (2100). However, the above negative effect on selected crops would be compensated, to some extent, by the positive effect of projected CO₂ increase in the atmosphere. The coastal region and the haor basin might be more vulnerable to changed climate compared to the central floodplain and the High Barind Tract area. These resulted from the combined effects and complex interactions of climate, soil, crop and management practices.

The sensitivity analyses of wheat yield to different parameters indicated that the yield may be reduced significantly due to increase in temperature, decrease in solar radiation, delay in sowing after 15 November, application of fewer than three irrigations, increase in soil pH and decrease in organic carbon content. Boro rice is also found to be negatively affected by increased temperature and decreased radiation (Mondal et al. 2012). But the above prediction was done based on all old varieties of wheat and rice. Such as the oldest wheat variety Kanchan has been considered, but recently BARI has developed a good number of wheat varieties (BARI Gom 25, BARI Gom 27, BARI Gom 30 and others recently developed varieties) having higher yield potentiality which could be sown in late condition (can endure increased temperature) and endure few degrees of salinity. While BR- 14 Dhan has been considered for prediction, but now BRRI/BINA has developed saline tolerant boro rice varieties such as BRRI Dhan 47, BRRI Dhan61, BINA Dhan10 having higher yield potentiality. Therefore, there is scientific/agronomic ways to minimize the ill effect of climate change through developing good adapted varieties, agronomic techniques, irrigation management, and adjusting the crop growth duration.

The groundwater aquifers in the coastal districts are under growing stress of salinization resulting from overextraction. Sea level rise and low river flows substantially contribute to that stress. Winter agriculture in the coastal areas is dependent on groundwater or stored non-saline surface water. Many of the anticipated adverse effects of climate change, such as sea level rise, higher temperatures, and an increase in cyclone intensity, will damage the forest resources of the country, put pressure on many climate-sensitive species, and cause increased erosion and deterioration of soil quality in many upland

forested areas. The world largest mangrove forest, the Sundarbans, is extremely vulnerable to climate change. Sea level rise will increase saltwater intrusion and negatively affect the forest. Smith et al. (1998) calculated that a 25 cm sea level rise would result in a 40% mangrove loss. Loucks et al. (2010) predict a 96% decline in tiger habitat in Bangladesh's Sundarbans mangroves with a 28 cm sea level rise if sedimentation does not increase surface elevations. Considering that the salinity regime inside the forest will significantly change as a consequence of climate change, it has been argued that increased salinity would have discernible adverse impacts on forest regeneration and succession (Khan et al. 2008).

Under climate change, people are exposed directly to changing weather patterns and indirectly through changes in the quality of water, air, and food; and changes in ecosystems, agriculture, industry, human settlements, and the economy. Water-borne diseases, such as diarrhea and dysentery, and vector-borne diseases, such as malaria and dengue, are climate sensitive. Climatic factors like temperature and precipitation are considered to be the key determinants of the distribution of many disease-carrying vectors.

Climate change will cause four major types of problems that will affect natural water resources of Bangladesh. The increased glacier melt due to higher temperatures will increase runoff from the neighboring Himalayas into the Ganges and Brahmaputra rivers. Given the altitude of the mountains and the enormous size of the glaciers, this problem will most likely continue over the century. The second problem is due to the increased precipitation as forecast by many climate models. While this is not certain, increase of precipitation would increase runoff in the Ganges, Brahmaputra, and Meghna rivers. This would aggravate flood-related disasters. The third problem is sea level rise, which will result in coastal flooding and prolong riverine flooding by causing more backing up of water in the three rivers. Finally, the increased intensity of cyclones and precipitation will enhance storm surges and coastal flooding.

4.2. Coastal farmer's perception about climate change, climatic risks and its impact on farming systems

As a concept climate change has widely been discussed among academics, researchers, governments and development workers but not so among the rural farming communities. However, rural men and women those who are mostly small and marginal farmers or fishers face the real challenges on their livelihood. As they mostly depend on rainfall, flooding, irrigation water, tidal water, temperature variation for their crops, afforestation, livestock and fish production. So, we must have a first-hand idea about farmer's perception about climate change and livelihoods effect as they face it recurrently (Table2)

Table 4.2: Farmers perception about some climate change indicators compared to 40 years back

Indicators	Villages of Southern Bangladesh					
	Biraljuri	Gaula	Ruhitalbunia	Sripur	Chadipur	Buri Goalini
Rainfall – amount and timeliness	Less rainfall , not timely	Less rainfall, erratic	Less rainfall, erratic, often huge at a time	Less and untimely	Less, erratic	Less, untimely

High heat wave	Increased, more in April-May and continue up to October	Increased round the year except winter-more in April-May	Increased	Increased, especially in April-May and up to October	Increased	Increased highly
Drought	Often in January-March	January-March	January-March	Dec-March	Dec-March	Not applicable-as change of land use pattern
Winter duration	Short-60 days(Dec-Jan)	Short, maximum 60-70 days	Only 40-50 days in Dec-Jan	Short only 60 days (Dec-Jan)	Very short	Very short
Tidal water-start and end	April-15 to Dec-15	April-15 to Dec-15	April-15 to Nov-15	April-15 to Oct-15	Within polder to protect from saline water	Round the year (10 months) except 15 Nov-15 Jan
Excessive tidal water	Less due to siltation of canals	Increased	A bit more	Increased suddenly	Not applicable	Often more
Tidal bore/cyclone	A bit more	Increased	More frequent	Increased	More	Increased
Water level of river/canals	More water height	Increased slightly	Increased	More	More	Increased by 2-3 feet
Soil and water salinity	Increased slightly	Increased	Increased	Increased	Moderately increased	Severely increased
Drinking water	Available	Available	Available but arsenic and salt affected	Available	Moderately reduced (salty)	Acutely reduced (salty)
Pest/diseases of crops/plants	Increased	Pest problem serious	Increased	Increased	Increased	Increased
Human diseases	Increased and many types of disease	Increased	More and various types disease	Increased	Increased	Increased
livestock and poultry diseases	Increased	Increased	Increased	Increased	Increased	Increased

Farmers of all the six locations think that rainfall has become more erratic in recent years, it doesn't start at time, and often one day rainfall is so huge that water logging/flooding occurs causing loss of crops and fish of pond and Ghers. Particularly, when the excessive rainfall occurs at the time of full moon or new moon. As in coastal area tidal water pressure is high during June-October especially at full and new moon time, so polder height must be uplifted and making it stronger. The drainage channel cannot drain out water of two sources (rain and tide). Farmers also think that rainfall is less than previous time but recorded data doesn't prove that. Farmers said that they are enduring unbearable heat wave for

seven months (April to October) and maximum in April and May. Probably due to high humidity the heat wave felt unbearable causing excessive sweating resulting in dehydration. And winter is now just for two months (December-January) which was 4-5 months (October/November-February) before 40 years back. In coastal area tidal water doesn't enter the crop field during Nov-March and which is also mostly rainless period thus drought conditions occur from December/January to March, but irrigation requirement is high in this period for rabi crops, vegetables, and boro rice.

In saline affected area river and canal water is unsuitable for irrigation due to high salinity (Khulna, Satkhira area) thus only depends on stored surface water. But in non-saline/slight saline area river and canal water could be pumped for irrigation for growing high value crops, but most of the land still remains fallow in rabi season (Barisal, Jhalokati, Pirojpur, partially Bagerhat). However tidal water intrusion (from 15 April) and receding remains almost similar to previous years though in some area it is hampered by unplanned road, culvert, housing and siltation of river, canal and creeks. In some area tidal water flow is excessive such as in Gaula, Ruhitalbunia, Sripur and BuriGoalini as those areas are exposed to big river and drainage canals. All the farmers believe that cyclone/tidal surge has increased over the years and water height of river has also increased even 2-3 feet more which might be an indication of sea level rise causing recurrent loss of lives, property, crop agriculture and livestock, houses, communication and institutions. Rashid et al. (2014) also reported similar opinion of farmers about climatic variation and climate change. Pest and diseases of crops/trees has increased markedly causing crop loss if corrective measures are not taken but often become costly to control it. Human diseases have increased largely with so many different diseases and treatment cost is huge and making active manpower ineffective thus heavy toll on livelihoods which pushing a greater number of marginal people below poverty level. Islam et al. (2011) identified increased human disease and health hazard because of changing climate and increasing salinity. All those discussed is the indicators of climate change causing negative effect on agricultural productivity, human health and overall livelihoods of the farming community.

4.3. Biophysical and socio-economic characteristics of the Villages

The studied area falls under Ganges tidal floodplains (Agro-ecological zone 13), major land type is medium highland having silt loam to silty clay soils (Table 3). The greater part of this region has smooth relief having large areas of salinity. In general, most of the topsoil's are acidic and sub-soils are neutral to alkaline. Soils of the Sunderban area are alkaline. Soils have medium to low organic matter content, very high CEC and K status but limitations of high exchangeable Na. The Zn status is low to medium but B and S status is high, but N and P status is very low to low (BARC, 2018). Thus applied N and P requirement is important to achieve higher yield of field crops, homestead vegetable and fruits along with organic matter.

There is wide difference among the villages for adoption of agricultural technologies, as the village Biraljuri and Gaula grows only one single local T.aman rice in monsoon, they don't need any irrigation, rather they depend on rainfall and tidal water. But other four villages have surface water irrigation facilities for boro rice and fish culture. Agricultural extension service is still sub-optimal or no service at village level and only few farmers have received any training on crop, livestock or fisheries. Only Sripur and Chandipur village people satisfy most of their rice requirement from own cultivation but other two village Biraljuri and Gaula meet only 20-25 % of their rice food security due to non-adoption of modern cultivars. The village Ruhitalbunia met 30 % of their rice need as some farmers adopted hybrid rice. While the village Buri Goalini has changed their major crop land to brackish Shrimp culture, so they cannot produce rice rather they depend on sell proceeds of shrimp and get some rice from land which is nearby to their village. Drinking water is a problem in village Ruhitalbunia due to arsenic and salt, Chandipur has more salt problem while Buri Golalini village has acute salt problem, they mainly

depend on harvesting of rain water through pond and plastic water tank fixed in their homestead. Communication to market has improved but still village Bilarjuri is 6 km from nearest market.

In most of the villages there is seasonal labor crisis as they have migrated to city, brick field and other places for more income. Traditional Bank loan is not available for famers within short time, but NGO loan is available with high interest rate. Except one village human and animal doctor is not available at local level, for getting treatment they have to move to city costing more with extra sufferings. Except the village Buri Goalini economic condition of farmer's improved over 1972 due to diversification of income including modernization of agriculture, service sector, small business, rickshaw/van pulling, working in foreign countries and big cities. In Buri Goalini village major crop land has been converted to Gher for sole Bagda shrimp cultivation which is mostly invested by outside big businessmen/fisher, locals get leasing money (those who have land), labor selling income at the cost of losing all other livelihood activities including cattle raring, fruit growing, vegetable growing, rice growing as the area is under saline water almost round the year. From Table4 it revealed that a big area of Satkhira farm land is converted mostly to saline shrimp Gher for Bagda shrimp where no rice crop could grow thus the area people suffer from rice food security-the main staple crop of the country. But Bagerhat and Pirojpur Gher mostly have rice and shrimp, additionally vegetable-fruits on the bank of dyke, so no negative effect on farmer's livelihoods rather farmer's income has increased.

Table 4.3: Bio-physical and socio-economic characteristics of the studied villages

Particulars	Villages of Southern Bangladesh					
	Biraljuri	Gaula	Ruhitalbunia	Sripur	Chadipur	Buri Goalini
AEZ	13	13	13	12, 13	13	13
Land type	Medium high	Medium high	Medium high	Medium high	Medium high	Medium high
Soil texture	Silt loam-clay	Silt loam-clay	Silt loam- clay	Silt loam - clay	Silt loam - clay	Silt loam-clay
pH	6.2-7.4	6.2-7.4	6.2-7.4	5.5-6.5	6.5-7	6.5-7
Soil organic matter	Low	Low	Low	Low-medium	Low-medium	Low-medium
Irrigation means	Tidally flooded in monsoon	Tidally flooded in monsoon	Centrifugal pump used for surface water	Centrifugal pump used for surface water	Centrifugal pump used for surface water	Centrifugal pump used for surface water
Agri. Extension service	No	Less	Very less	Rare	Available	No Govt. service but NGO
Received agricultural training	Not	9%	5%	Not	10 %	80 % from NGO
Modern technology adoption	Only small in case of rice variety	Very low	Good for rice and vegetable	Good for rice, vegetable , gher	Good for rice and vegetable	Partial for Bagda shrimp
Quality input availability	Less	Less	Hybrid rice only	A bit available	Not good quality	A bit available

						PL of Bagda but costly
Rice food security	20 % of whole year, rest have to purchase for different months	25 % of whole year	30 % of whole year	95 % of whole year	85% of whole year	25 % from own rice (from other village have rice land)
Drinking water security	Good	Good	Arsenic and slight salt affected	Good	Salt problem	Severe salt problem (rain water harvest)
Communication with market	6KM	1Km	0.5 Km	4 Km	2 KM	1Km
Agril. Labor availability	Seasonal crisis	Seasonal scarcity	Less	Available	Scarce	Available
Bank/NGO loan availability	Only NGO	Only NGO	Only NGO	Only NGO	Only NGO	NGO loan for small farmers
Human and animal doctor availability	Only Quack	Less available	Moderate	Only Quack	Available as near Upazila	Only quack
Economic condition compared to 1972	Better	Better	Better	Far Better	Better	Bad due to Bagda shrimp cultivation. Profit goes to big investors
Farm category	Landless-small	Landless-small	Landless-small	Landless-small	Small	Marginal/landless

4.4. Salinity

It has a profound negative effect on the ecosystems, agriculture, livestock, fisheries, forest and health of the people. About 87 % of cultivable land of Bagerhat is saline, 81 % of Satkhira, 8 % of Jhalokati and 42 % of Pirojpur. Over the four decades salinity has increased 21% at Bagerhat, 5 % at Satkhira, and more area of Pirojpur and Jhalokati are becoming saline (SRDI, 2010) due to withdrawal of Ganges sweet water in upstream by India through Farakka barrage, secondary salinity and breaching of polder by saline water through cyclonic storm like Sidr and Aila. Major saline area of Bangladesh is in southwest (shown in saline area map, Fig 16.) mainly due to low sweet water flow from upstream particularly from Padma (Ganga) and its main tributary-Gorai/Madhumati. Rice and few other crops can by and large endure 4-8 dS/m salinity, but it become difficult for most of the crops and plants to grow and produce economic yield under excessive soil and water salinity such as; 8-12, 12-16 and >16 dS/m salinity (Table 6). However, Bangladesh scientists developed few varieties which are tolerant to 8-12 dS/m salinity; such as BRRIdhan27, BRRIdhan 61, BINAdhan10. From Table 4 it shows that a significant portion of cultivable land of Bagerhat and Satkhira is under above 8 dS/m salinity where it is difficult to grow good crop except during monsoon (June-Sept).

Moreover, in such salinity many fruit trees and crops cannot grow limiting the biodiversity, nutrition and income of residents, moreover human and animal becoming sick due to water related different diseases (Islam et al, 2011). Additionally climatic model suggests that in future soil and water salinity would increase in the coastal belt of Bangladesh which may cause decrease of crop yield as much as 50 % threatening the livelihoods of millions of farmers of the coastal region if adaptation measure is not taken (Clarke et al., 2015). Excessive salinity will also decrease the production of shrimps and other coastal belt fish species, which may largely affect the livelihoods of coastal area small scale/large farms owners and reduce national production, as aquaculture is one of the major income source coastal farmers and fishers (Table 5). Seasonal variation in soil salinity is quite distinct; top soil salinity gradually increases from January, reaches a maximum usually in April or May, and then starts to gradually decrease with the onset of monsoon and reaches the seasonal low usually in September or October when salts are sufficiently flushed out by monsoon rainfall. However, at some places greater accumulation of salts occurs due to a combination of the factors listed in Table 7 along with management of water salinity. Therefore, development of saline tolerant crops and/or saline soil management technologies is crucial for successful adaptation efforts for Bangladesh coastal region.

Table 4.4: Soil salinity class and area under different southern districts of Bangladesh

District	Total cultivated area(ha)	Total saline area(ha)*	Salinity class and area(ha)				
			S1(2-4 dS/m)	S2(4-8 dS/m)	S3(8-12 dS/m)	S4(12-16 dS/m)	S5(>16 dS/m)
Khulna	165789	147960(89%)	24640	26880	31800	33970	30570
Bagerhat	150744	131120(87%)	31330	41390	29890	19270	9240
Satkhira	188626	153110(81%)	30000	31960	30650	31920	28580
Jhalakathi	55895	4620(8%)	3700	920	-	-	
Pirojpur	85282	35830(42%)	23110	9940	2780	-	

Source: Saline soils of Bangladesh, SRDI, 2010*Percent of total cultivated area

Table 5: Information on land area, fisheries area and fish production

Item	Jhalokati	Pirojpur	Bagerhat	Satkhira
District area(ha)	73916	127808	201331	229607
Cultivated land(ha)	55895	85282	150744	188626
Fisheries area(ha)	13915	45789	99756	88734
Total fish production(t)	7852	25884	95952	121811
Bagda gher area(ha) and production(t)	-	-	46724 (13594)	66862 (19273) *
Golda gher area(ha) and production	-	1075 (663)	18868 (8841)	9338 (5925)

Data source: BBS (2021), SRDI (2010), DOF (Jhalokathi, Pirojpur, Bagerhat and Satkhira)

*Figure in parenthesis indicates production in metric ton

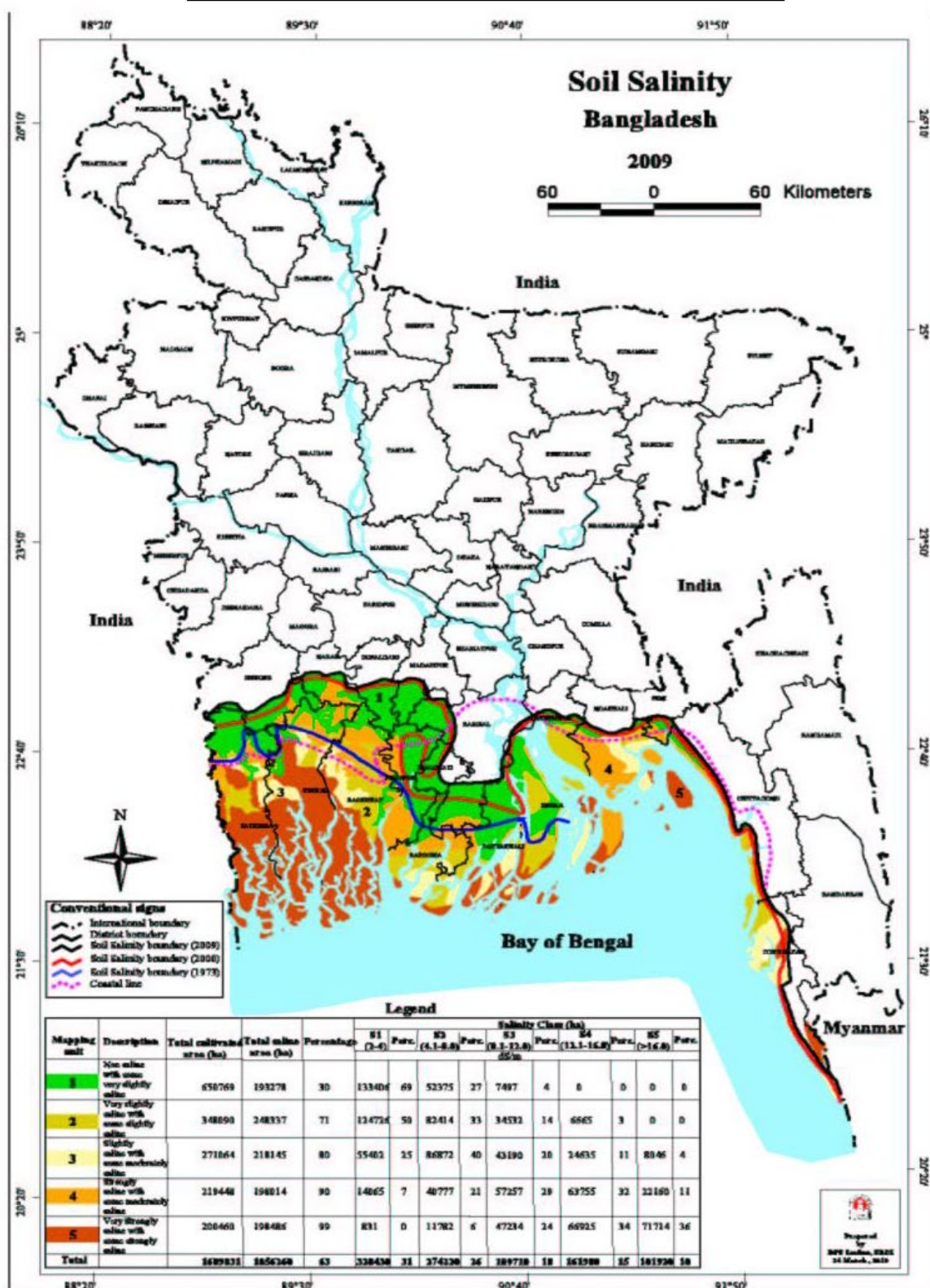
Table 6: Relative tolerance of some plants/crops to soil salinity (Tisdale al., 1997)

Tolerant (8-12 dS/m)	M. Tolerant (6-8 dS/m)	M. Sensitive (4-6 dS/m)	Sensitive (0-4 dS/m)
Barley, Grain	Barley, Forage	Broad Bean	Bean
Cotton	Beet, Garden/Red	Cabbage	Blackberry
Date	Cowpea	Cauliflower/ Broccoli/ Klnkhol	Carrot
Salt Grass	Clover, Berseem	Clover, Strawberry	Lemon/ Mango
Rosemary/ Jujube	Fig/ Coconut/ Guava	Maize	Onion
Sugar Beet	Oats/ Pineapple	Cowpea/ Watermelon/ Muskmelon/ Radish	Orange
Triticale	Orchard Grass	Cucumber/ Papaya	Pineapple, Guava?
	Sorghum	Lettuce/ Spinach	Rose
	Soybean	Pea	Strawberry
	Wheat	Peanut/ Garlic	Mungbean
	Dhiancha	Potato	
	B. Napus	Rice, Paddy	
	Soybean	Tomato	

Table 7: Salinity mechanisms and processes in coastal Bangladesh (adapted and modified from Salehin et al., 2018)

Mechanism/ drivers	Processes of Salinity	Long-term change factors	Management of water salinity
Climate variability	Irregular rainfall (less rainfall not being able to flush out salts in monsoon; less rainfall forcing more irrigation in dry season)	Increased irrigation	Availability of non- saline surface water for irrigation
Groundwater salinity	Accumulation of salts from capillary rise of saline groundwater table	Increased sea levels Increased River salinity Increased pumping in upstream freshwater zones	Increase volume of upstream river water flow. Reduce pumping of ground water in upstream
Depth to water table	Capillary rise (water table is < 2 m from surface)	Increased pumping	Decrease uplifting of ground water in upstream
Cyclonic storm surges	Overtopping of polders Trapped saline water in low-lying floodplain areas with silted up drainage canals Persistent inundation of tidal plains through embankment breaches	Sea-level rise Higher sea levels Increased frequency of surges	Make the polder stronger and increase of its height as per need
River water salinity	Direct tidal inundation in unprotected areas Tidal inundation in polders through embankment breach and/or due to faulty water control structures and poor management Lateral seepage of saline river water through soil/embankment	Reduced river flows due to climate variability Reduced River flows due to upstream diversion Reduced River flows due to upstream dams	Make the polder stronger and increase of its height as per need. Sluice gate should be properly maintained to avoid saline water intrusion. Regular monitoring and repair of embankment with local people active participation
Salinity of irrigation water	Irrigation with saline river or groundwater	Sea-level rise Increased irrigation for leaching Saline intrusion into groundwater aquifers	Must avoid irrigation by saline water. Increase upstream river water flow
Brackish shrimp cultivation	Deliberate introduction of saline water inside polders Lateral seepage from shrimp ghers to adjacent land Contamination of shallow groundwater	National policies Market forces/prices Power relations	Need strong government policy and its implementation to save land and water from artificial salinity by shrimp traders

Figure 16: Map showing saline area of Bangladesh coastal region



4.5. Cropping systems and yield gap

From Table 8 it is observed that there is wide variation among the villages for accepting modern rice varieties. Those villages which adopted modern boro or hybrid rice have significantly increased their rice yield resulting in fulfillment of their stable food security need and reduction of poverty. However, village Biraljuri farmers are following the same cropping pattern in 2021 like they followed in 1980. So, their yield level of rice is only around 3 t/ha and they are cultivating only one crop per year, keeping the land fallow in rabi season. Thus, the productivity of land is very low. They are growing traditional long duration photo-sensitive varieties whose genetic yield potentiality is low. Still yield gap is more than 52 % due to management problem. On the other hand in 1980 Gaula village farmer have two crops per season T. aus-T. aman rice but they abandoned T. aus rice in 2015 due to high cost of T. aus rice production. Now they cultivate only one local T. aman rice like Biraljuri having poor yearly production. Yield gap is 27 %. Low market price of rice at season and high production cost (labor, irrigation, fertilizer, pesticide) has made T. aus non-lucrative to Gaula farmers. For cultivating T. aus hard cash is needed which often the marginal farmers lack. With changing climate and demographic demand and availability of modern technology the farmers of Ruhitalbuni have adopted modern hybrid boro rice varieties instead of traditional T. aus rice whose yield is only 2-3 t/ha whereas yield of hybrid boro rice is up to 12.3 t/ha (7 ton/ha average yield) at farmers level. However, they kept the T. aman rice as usual for getting the benefit of high tidal water during monsoon and having a better tasty dish with local “Shail” rice compared to HYV rice. But yield gap (53 %) of hybrid boro rice among the farmers is too high due to seed quality, planting time and management problem. Introduction of hybrid boro rice has largely improved the rice food security of the villagers (Table 3) paving the path of better livelihoods. However, production cost of hybrid boro rice is very high (seed, fertilizer, irrigation, pesticide, weeding) in comparison to local T. aus rice where only cash cost is seed/seedling cost. Sripur village farmers have intensified their cropping system almost from one crop to three crops.

Traditionally they practiced Grass pea/ Fallow-T. aman in 1980s but now they grow Boro-T. aman and Grasspea-Boro-T. aus-T. aman having high per unit land productivity and ensuring food security. For Boro, T. aus and T. aman rice they have adopted high yielding varieties often short duration variety for T. aus rice to adjust with the cropping pattern. However, yield gap in boro rice is high (46%) and in T. aman moderate (25 %). In Chandipur the major cropping pattern almost remains the same but in 2010s they have introduced high yielding varieties of T. aman rice instead of local T. aman varieties for achieving higher yield. They are getting 3.6-5.5 t/ha yield from modern T. aman compared to only 2.5-3.1 t/ha from local aman rice. However, yield gap is high (34%) for modern T. aman rice among the farmers. Reasons of yield gap are mentioned above. By changing this one variety of a single crop they have almost ensured their rice food security (Table 3). Brui Goalini villagers completely changed their land use pattern by introducing brackish shrimp (called Bagda) instead of T. aman rice. Their whole ecosystems have changed except in homestead, no edible grass, tree, crops, or vegetables. Their rice food security depends on regular purchase from market from the sell proceeds of shrimp and other works. However, shrimp yield is often completely devastated by White spot virus and other diseases. Farmers have no cattle as there is no grazing place all the area is flooded by saline water. Local farmers depends on lease money from shrimp farming which is mostly run by big investors, labor selling in shrimp farm, small business, rickshaw-van pulling and legally or illegally collection of Sunderban’s forest products, honey and fishing. The local farmer’s livelihoods have deteriorated compared to pre-shrimp farming in 1980s along with more health problem due to saline water introduction in the entire crop field and total environment of the area is salinity affected even the wind. There is yield gap (33 %) in Bagda shrimp production due to quality of larvae and management.

4.5.1. Cause of Rabi season Fallow

Major reasons (Table 9) of rabi season fallowing are uncontrolled tidal water damage the rabi crop, cultivation of long duration rice which keeps the land occupied during optimum time of rabi crop sowing, free grazing of cattle, some area farmers lack of hard cash to purchase input, idleness, less exposure to modern technology and in some coastal area there may be drainage problem. Solutions are mostly community based such as controlling the sluice gate of polder/embankment; avoid free grazing of cattle and take initiatives; while hard cash problem could be solved through soft and harass less credit facilities to smallholders ahead of cropping season along with supply of modern technology such as good quality seeds and fertilizers and hands-on farmers training.

Table 8: Crops and cropping patterns with varieties and their yields at different villages of southern Bangladesh during 1980 and 2021

Location	Cropping pattern*		Crops/variety		Yield (t/ha)		Remarks
	1980	2021	1980	2021	1980	2021	
Biraljuri, Pirojpur	F-F-T.Aman	F-F-T.Aman	Sada Mota, Lamota, Kazolshail	Mala, Abdullah, BRRIdhan -23, Sada Mota	1.5-2.5	1.5-3.1	Very low adoption of modern technology
Galua, Jhalakathi	F-T. aus-T. aman	F-F-T. aman	T. aus: T. aman: Sada Mota, Lalmota	Sada Mota, Lalmota, Balam	T. aman: 2-3 T. aus: 1.5-2.5	2.25-3.1	Very low adoption of modern technology
Ruhitalbunia, Pirojpur	F-Taus-T.Aman	Boro-T.Aman	T. aus: T. aman: Sada Mota, Lalmota	Hybrid: HIRA, Rajkumar, Swarna	T. aman-2-3 T. aus: 1.5-2.5	Hybrid Boro: 5.8-12.3	Good adoption of hybrid varieties in rice
Sripur, Bagerhat	Grasspea/F-T.Aman	Boro-F-T. aman Grasspea-Boro-T. aus-T. aman	Sadamota, Lalmota	Boro-BRRI dhan28, BRRIdhan 47 T. aus: Prbachhi T. aman: BR10, BR11	T. aman: 2-3.5 Grasspea : 1-1.7	Boro: 4.5-8.4 T. aus: 3 T. aman : 3-4 Grasspea: 1.0	Very intensive cropping systems, poverty reduced markedly
Chandipur, Satkhira	F-F-T. aman	F/Grasspea-F-T.Aman	T.Aman (Local)	BR10, BR11, BR22, BRRIdhan 49	T.Aman (Local): 2.5-3.1	3.6-5.5	Medium adoption for modern T. aman rice cultivars

Buri Goalini, Satkhira	F-F-T.aman	Bagda shrimp only	Taman (Local)	Bagda: 0.6-0.9	T.aman(L)-3.2	Bagda shrimp: 0.6-0.9	Only saline shrimp farming devastating total ecosystems. Good for absentee big businessmen. Created health problem for local residents
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*F means Fallow land. By each hyphen each crop per season is described. In cropping pattern column generally by two hyphens three crops are separated. As in a single years three crops are grown in Bangladesh on same piece of land

Table 9: Rabi season fallow area and its causes and probable solutions for southern Bangladesh villages

Location (villages)	% Area main fallow in Rabi	Causes of remaining fallow	How fallow area could be brought under cultivation
Biraljuri	95	Farmer's idleness, cash money problem, tidal water and free grazing, long duration aman crop	Community basis arrangement to control water and grazing of cattle. Set block demonstration of suitable crops. Involve local administration (DAE/WDB)
Gaula	99	Manage tidal water, free grazing, long duration aman crop	Community basis arrangement to control water and grazing of cattle. Set block demonstration of suitable crops. Involve local administration (DAE/WDB)
Ruhitalbuia	20	Sudden intrusion of tidal water damage rabi crops in normal slope lands. Converting land to vegetable+rice + fish gher for maximum use. Initial cost of gher preparation is high.	Help farmer to maximize gher and other areas for vegetable and high value crops
Sripur	50	Lack of initiative, free grazing, less duration available, irrigation, tidal water control	Community basis arrangement to control water and grazing of cattle. Set block demonstration of suitable crops. Involve local administration (DAE/WDB)
Chadipur	70	Tidal water, free grazing	Sluice gate control to prevent saline water intrusion, dig canal inside polder to preserve rain water, set community-based demonstration
Buri Golalini	01	-	Land under saline water for shrimp farming

4.5.2. Homestead plantation and livestock

Except Buri Golalii village homestead fruit, timber tree and vegetable cultivation and diversity increased, however less production from each type because of excessive plant population and farmers are not following scientific management (Table 10). As Buri Goalini villagers changed the upland ecosystems to brackish wetland ecosystem no normal plant can grow in saline water inundation situation. Cattle number and other livestock reduced significantly in all the area mainly due to lack of space, grazing place, cost of animal rearing and diseases. However, in few places poultry and goat increased. Buri Goalini household has almost no livestock because of saline land and water. Thus, it has a negative effect on the nutrition, cash income, women employment and livelihoods on smallholders.

Table 10: Situation of homestead vegetable, fruit-timber trees and livestock

Items	Villages of Southern Bangladesh					
	Biraljuri	Gaula	Ruhitalbunia	Sripur	Chadipur	Buri Goalini
Homes-tead vegetable	Cucurbits, okra, Indian spinach, red amaranth, radish, turnip, chilli etc.	Cucurbits, Indian spinach, okra, country bean, radish, chilli etc.	Cucurbits, cucumber, okra, yard long bean, kolmi sak (Kangkong)	Cucurbits, okra, Indian spinach, red amaranth, radish etc.	Brinjal, chilli, cucurbits, papaya, okra, radish, cucumber, onion, knolkhol	Cucurbits, radish, chilli, Indian spinach, okra
Fruit tree	Sapota, mango, banana, coconut, betel nut, lemon, jack fruit etc. But bearing decreased due to high population and lack of management	Sapota, coconut, betel nut, lemon, velvet apple, lemon, ber, jack fruit, banana mango. But bearing is poor due to high population of trees and lack of management	Coconut, betel nut, mango, banana, lemon, sapota. Low bearing due to high timber population, bad seedlings, lack of management	Mango, banana, jack fruit, coconut, betel nut, lemon, sapota. Low bearing due to high timber population, bad seedlings, lack of management except for banana (as in field)	Coconut, mango, jack fruit, sapota, wood apple, betel nut, banana, ber, date palm	Sapota, coconut, ber
Timber tree	Mahogany, different Kori sp.	Mehogany, different kori sp. bamboo	Mahogany, different Kori sp.	Mahogany,	Mahogany, different	Mahogany, Neem

				different Kori sp.	Kori sp., Neem	
Livestock population	Except poultry others -cow, goat decreased markedly	Except poultry cow, goat decreased markedly	Poultry and goat increased but cow decreased	Poultry and cow increased but buffalo and goat decreased	Only goat increased. Poultry same but cow and buffalo decreased	All kinds of livestock drastically reduced due to salinity and scarcity of grass/rice straw

4.5.3. Pond and Natural fish availability

Bilarjuri and Gaula pond owner depend on natural fish through linking the pond with tidal canals and rivers (Table 11). But other areas pond owner cultivates mainly mixed culture of common carp species and Tilapia. Fish availability decreased largely in rivers, canals and crop field where tidal water enters mainly due to overfishing, destruction of safe sanctuary of fish and excessive use of pesticides in rice crop along with increasing of salinity during dry season. In pond farming there is wide variability of profit from 1.5 to 6-7 hundred thousand BDT per hectare. So, there is scope to improve the pond productivity and profitability through practice of modern fish farming. Farmers also suggested ways of changing the decreasing natural fish availability such as, by digging canals and water bodies, free flow of water, use of IPM in rice field, refrain from catching fish egg and brood fish and avoid use of small mesh fish net.

Table 11: Backyard Pond use for aquaculture and natural fish availability

Indicators	Biraljuri	Gaula	Ruhitalbunia	Sripur	Chadipur	Buri Goalini
Pond aquaculture	90 % no cultivation rather looks for naturally coming fish through linking pond to tidally flooded nearby canals	90 % no cultivation rather looks for naturally coming fish through linking pond to tidally flooded nearby canals	Not pond based but gher based	70 % pond cultivated for fish-mixed culture	90 % cultivates mixed species	70 % cultivates who have pond
Profitability of pond aquaculture	N/A	N/A	N/A	6-7 hundred thousand BDT/ha (commercial)	2.5 hundred thousand BDT/ha	1.5 hundred thousand BDT/ha
Availability of natural fish in river/canal/ water bodies	Less	75 % less than previous years	Less	Less	Very less	Less
Fish species diversity	Reduced significantly	Largely reduced	Reduced seriously	Reduced	Seriously reduced	Heavily reduced

Seasonal availability of fish in tidally flooded cultivated land	Drastically reduced	Very few	Rarely available	Less available	Very few	N/A due to changed land use
Way of increasing natural fish population	Free water flow in canals, less capture during brooding time	Canal and water bodies digging	Motivate not to catch egg bearing fish in March-April, use of IPM in crop and reduced pesticide use	Not to use thick mesh net, IPM use	Excavate canals and ponds	Very difficult

4.6. Climate smart agriculture for resilience and adaptation

Farmers regularly and recurrently face the climatic variation, cyclone, tidal surge, intrusion of saline water to crop field and homestead destroying life, properties, dwelling house, livestock, trees and crops in the coastal belt of Bangladesh. As Bangladesh is a small country having one of the highest population densities of the world, it has few places to live. Thus about 40 million people lives in the coastal belt which is close proximity to sea, big tidally flooded river, canals and creeks. So, they are easily exposed to this damage and destruction making their livelihoods terrible. However, the resource poor people/farmers/fishers have no places to move but they have to adjust with the changing climatic variation and climate change. As the coastal belt is in a remote place of the country, first hand research output rarely reach there quickly, rather it reaches there very slowly. But residents have to face the climatic odds very day. For facing these challenges local innovative farmers have developed many technologies to adapt with the situation as well as to improve their agricultural productivity and profitability. Researchers are trying to improve some of those technologies (BARI, 2007). Table 12 depicts some of them. Ali (2014) described in details the high profitability of Gher system for mixed agriculture (Shrimp+ other fish+ T.aman/Boro rice+ vegetable on dykes) instead of traditional sole monsoon T.aman rice. This farming system also helps to improve the land productivity, biodiversity and change of this land utilization has ensured the people to rise out of poverty level ensuring food, nutrition security and enhanced income. Because except the catastrophic cyclone like Sidr/Aila this system of land use can protect most of tidal surge, excessive rainfall or natural disaster by protecting the area through dykes, thus many coastal belt farmers are accepting this option though initial Gher preparation cost is a bit high. On the other hand, Saline water Gher system for sole Bagda shrimp cultivation is popular among big businessmen and big farmers (mainly Khulna, Satkhira area) at the cost of destroying the whole ecosystems and other livelihoods options like rice, vegetable or livestock rearing (<https://www.linkedin.com/in/yusuf-ali-74b08154>). The marginal and landless farmers have become labor due to this system leaving few options for them to live. The system of Bagda farming is highly profitable as there is export market, but condition is that it would not be affected by deadly virus disease-White spot. However, it frequently and recurrently affected by the above disease leaving many entrepreneurs to bankruptcy. Sarjon method of cultivation (making high ridge and small canal) is an age old practice across the tidally flooded area (BARI, 2011), mainly practiced by farmers of Barisal, Jhalokati, Pirojpur, Patuakhilai and other coastal area) to grow vegetable, banana fruit/timber tree in ridge and sometimes fish in canal. However, it faces soil erosion and become less productive within few years and then farmers plant timber/fruit/betel nut tree on it. Boro rice has been introduced in winter season by the researchers, development workers and farmers across the country to ensure higher yield

and to avoid flood/cyclone of summer and monsoon. Thus, presently boro rice is the major way of rice food security for Bangladesh people. Farmers of Ruhitalbuni and Sripur have also adopted this option and largely meet their rice demand just by shifting to boro rice from Aus or fallowing the land and T.aman has become secondary crop. This has a huge impact on food security, poverty reduction and livelihoods improvement though cultivation cost of boro rice is high. Other options are for saving the homestead and houses from cyclone, tidal surge as well as to grow fruit/timber tree and homestead vegetables for increasing land productivity, family nutrition and income.

Table12: Farmers own adaptation measure against climatic variations and climate change

Technology/ Adaptation	Biraljuri	Gaula	Ruhitalbunia	Sripur	Chadipur	Buri Goalini
Gher system cultivation for mixed agriculture	-	-	Considering it as a highly efficient measure against sudden surge of tidal water for growing vegetable, fruit tree, rice and fish	Considering it as a highly efficient measure against sudden surge of tidal water for growing vegetable, fruit tree, rice and fish	-	-
Saline water Gher system cultivation for sole Bagda shrimp	-	-	-	Good area is under sole Gher replacing all crops/other livelihood options	-	Largely adopted across the areas replacing all crops/other livelihood options
Sarjon method of cultivation	Adopted in small area for cultivating vegetable, fruit trees, timber tree and often fish against tidal surge	Adopted in small area for cultivating vegetable, fruit trees, timber tree and often fish against	Adopted in small area for cultivating vegetable, fruit trees, timber tree and often fish against tidal surge	-		

		tidal surge				
Shifting the rice growing time in winter and pre-monsoon period	-	-	Boro rice is less affected by natural calamities compared to Aman having higher yield	Boro rice is less affected by natural calamities compared to Aman having higher yield	-	-
Uplifting homestead area	All homestead is on raised land, so that houses and yard is saved from high tidal and rain water	All homestead is on raised land, so that houses and yard is saved from high tidal and rain water	All homestead is on raised land, so that houses and yard is saved from high tidal and rain water	All homestead is on raised land, so that houses and yard is saved from high tidal and rain water	All homestead is on raised land, so that houses and yard is saved from high tidal and rain water	All homestead is on raised land, so that houses and yard is saved from high tidal and rain water
Creating a green barrier by planting dense large trees	To save the houses and property from coastal storm along with getting cooking fuel, timber and fruits	To save the houses and property from coastal storm along with getting cooking fuel, timber and fruits	To save the houses and property from coastal storm along with getting cooking fuel, timber and fruits	To save the houses and property from coastal storm along with getting cooking fuel, timber and fruits	To save the houses and property from coastal storm along with getting cooking fuel, timber and fruits	To save the houses and property from coastal storm along with getting cooking fuel, timber and fruits
Build the houses having less height	To save from storm	To save from storm	To save from storm	To save from storm	To save from storm	To save from storm

Besides the farmers innovative idea, we have divided available adaptation technology options viz. a. for homestead, fisheries and Gher; b. for field crops. Along with name of technology, its advantage, broad applicable area/farm and name of the technology developer with reference has been mentioned in Table 13 and Table 14. Based on the farmers situations, land type, economic condition, food habit, seed/technology and market, suitable technology for each farm may be selected and tested.

Table13: Available adaptation technology options for homestead, fisheries and Gher against climatic variation and salinity/tidal water

Name of the technology	Advantage	Applicable area/farm	Who developed/promoted
Homestead vegetable model	Saline tolerant and creeping vegetable could be grown round the year meeting mostly family nutrition along with small sell. In general women are engaged	All the south-west coastal area	BARI (Ali et al. 2014)
Tower system vegetable production/Sac gardening	About 1.2 m height and 1.3 wide tower is built surrounded by polyethylene and bamboo filled by soils, organic compost and others. Also used sac is used for this purpose. Through this method mostly vegetable crops can avoid tidal water surge, water logging, excess rainfall, even drought	All coastal area particularly in homestead or near homestead. Women and children mostly manage.	Hossain et al. (2015) BARI (personal communication with Md. Atiqur Rahman, Scientist, BARI, Banerpota farm)
Ring setting at tidally flooded land for capturing visiting fish	With the onrush of tidal water from April-15 different fish species particularly broods take shelter to this ring (3-5 ft depth) water and save itself from hot sun and from immediate catching. Thus it becomes able to lay eggs. Also farmers able to harvest 3-4 kg fish per season per ring	All tidally flooded crop lands	CCAFS, Personal communication Emdad Hossain
Growing vegetable in Gher boundary including <i>Moringa</i> tree	Can produce a significant amount of different vegetable round the year fetching a good dividend as well family nutrition	All mixed Gher area of Pirojpur, Bagerhat, Khulna and Satkhira	BARI (2007)
Banana cultivation	For saline and tidally flooded non-saline area on homestead and raised land	Coastal area	BARI, 2015 (personal communication with Md. Atiqur Rhman, Scientist, Banerpota farm)
Summer Tomato on homestead (BARI hybrid tomato 4)	On raised slight saline and non-saline soils. Highly remunerative even for small area	Selected coastal area and trained farmers	BARI, 2015 (personal communication with Md. Atiqur Rhman, Scientist, Banerpota farm)

Table 14: Available adaptation technology options for field crops against climatic variation and salinity/tidal water

Name of the technology	Advantage	Applicable area/farm	Who developed/promoted
Saline tolerant Boro rice cultivation (BRRI Dhan- 47, BRRI Dhan- 53,55, 63, 67, 97,99 BINA Dhan 8, 10)	Can tolerate moderate – high salinity at different stages of crop (8-10 dS/m). It can yield up to 6-7 t/ha	All the south-west coastal area	BRRI (2015, 2022), BINA (2015)
Submergence tolerant Aman rice variety (BRRI Dhan 52)	Less seedling damage and can remain 12-14 days under non-saline water having 4-5 t/ha yield	Non-saline or less saline areas	BRRI (2015)
Wheat cultivation after fallow/T.aman (BARI Gom25, 26, 27, 29, 30)	3-4 t/ha yield within 102-110 having less water requirement	Non-saline or slightly saline area of coastal region where land become ready for cultivation/strip tillage within December	BARI (2011), Personal communication Harun-Ur-Rashid, Scientist, BARI, Daulatpur, Khulna
Mustard cultivation (BARI Sharisa 14)	Within 75-80 it can give 1-1.5 t/ha yield. Require small irrigation/rainfall	After fallow/T.aman mustard planted/relayed within December produce good yield having multiple use oil and its cake along with good market price. As short duration it can avoid soil salinity.	BARI (2011)
Lentil (BARI Masur 5/7/8)	Could be harvested within 110 days having 1-2 t/ha yield. The costliest crop having huge market demand. High and easily digestible protein rich pulse	The land where water recedes within December could be planted /relayed in soft soil. As short duration can avoid soil salinity	BARI (2011), Personal communication Harun-Ur-Rashid, Scientist, BARI, Daulatpur, Khulna
Cultivation of watermelon and other cucurbits by irrigating non-saline surface water	Highly remunerative (net return: 11000BDT/ha) and requires small water only at the base of each plant. Later its creepers serve the purpose of live mulch thus salinity is checked and drought is avoided. Women engaged in irrigating by bucket. Pheromone trap used to control fruit fly	The land where water recedes within December and tidal water cannot reach It is only 100 days crops	BARI (2013), Ali et al. (2014)

Zero/strip tillage maize cultivation (BARI Hybrid Bhutta 5/7/9, other commercial hybrids)	Can produce a yield of 5-6 t/ha in slightly saline soil and up to 8-12 t/ha in non-saline soils of coastal area, leaves used as fodder and stem as fuel. Both human, animal, fish and poultry food/feed	Could be planted up to Mid-January in coastal upland area. Requires small irrigation/rainfall	BARI (2013), CIMMYT-CSISA (2014)-Personal communication Muhammad Shahjahan S.Al-Emran(CIMMYT)
Sesame cultivation (BARI Til 4)	Could be planted in January-February. Good yield (1-2 t/ha) and have good market price	A bit higher elevated land where tidal water cannot come with Jan-April and rain water drain out quickly	BARI (2013)
Potato cultivation in raised bed with mulch (Diamant, Cardinal)	Have a yield of 25-30 t/ha with 80 days. Use of straw/other much served the purpose of irrigation and can avoid developing salinity	A bit higher land where water recedes within Mid-December. Could be grown non-saline/moderate saline soils of coastal area	BARI (2013)
Mugbean(BARI Mung 6) cultivation after T.aman rice	Can be plated in February having 1-1.5 t/ha yield within 60-80 days. Good market price and protein rich. Crop canopy can reduce salinity and drought. Women engaged in pod picking.	A bit higher land where rain water does not stand and tidal water cannot enter within April.	BARI (2013)
Sunflower cultivation after rice (Hysun33)	Could be planted in Dec-January after the harvest of T.aman rice either under tillage/zero tillage situations. The crop is saline tolerant.	High quality edible oil source having good market price. Requires small amount of irrigation. Land should be well drained and tidal water free	BRAC (Personal communication Sirajul Islam), WLE-IRRI project (Manoranjan Mondal)
Late Rabi season Tomato (BARI Tomato 14)	Could be planted up to 30 December having 50-60 t/ha fruit fetching good profit	Land of a bit higher elevation where rain water doesn't stand and tidal water don't reach up to April 15. Need small irrigation and can endure sight to moderate salinity	BARI (2011), and Personal communication with Md. Atiqur Rhman, Scientist, Banerpota farm)
Floating agriculture in tidally deeper flooded area (Farmers Innovation)	Farmers developed this system for vegetable seedlings production and for producing few vegetables/spices crop. Profit margin is 6-7	Farmers of Barisal (Banaripara), Pirojpur (Nazirpur, Sarupkathi), Jhalokathi(Sadar) and Gopalganj(Tungipara	Farmers survey by Ali et al. (2014)

	times higher than T.aman which is around 200K BDT/ha	) practice it widely instead of sole Aman rice	
Local aman rice + Fish	Farmers highly benefited by seasonal fish cultivation within rice field without much investment. Fish reduce weed infestation by eating	Aman rice field within polder having access to nearby canal/seasonal ditches/water bodies	WLE funded IRRI project experience on community rice-fish cultivation at Khulna polder ³⁰ .
Water chest nut (Pani Fall) production in shallow standing water	Farmer using their unused fallow pond/ditches to produce this crop having good market price	Fallow water bodies of Satkhira and elsewhere of Bangladesh. BARI researchers developing GAP	Personal communication with Md. Atiqur Rhman, Scientist, Banerpota farm)
Axial Flow pump for surface irrigation	Above 40 % diesel fuel efficient than traditional Centrifugal pump	Could be applied for surface irrigation of tidally flooded area where water level is within 3m	Ali (2014), Shah-Al-Emran, CIMMYT, Barisal

4.7. Climate Smart Agriculture (CSA) promotion through Climate Smart Village (CSV)

From 1980s BARI, BRRI and other research institutes of Bangladesh under NARS is endorsing the establishment of Cropping Systems/Farming Systems Research and Development site/ village across the major agro-ecological zones to promote location specific technologies/crop varieties/livestock breed/fish species/homestead gardening/agroforestry (Chowdhury et al. 1993) through different donor's fund including WB funded ARMP-which was a mega project. Recently NCCB-2022 (Network on Climate Change in Bangladesh) has also emphasized the location specific adaptation plan dividing Bangladesh into 12 parts. BARI has more than two dozen of technology villages across the country to promote its technology quickly among the farming community (BARI, 2011). So, for targeting a specific area development selection of some specific villages is important. It works as a hub to quickly test/promote/adapt/disseminate modern technologies among the rural farming communities through hands-on training/action research/participatory on-farm trial/village climate information center/result demonstration/technology advice/field day/meeting/exposure visit etc. Moreover, the coastal area of Bangladesh is remote where rarely recently developed varieties/species/technology reaches to farmer's end, particularly when they are largely affected by climate change effect compared to other parts of Bangladesh. Setting of some community-based CSVs could be pilot area for adapting/disseminating available CSA options, and it may act as mini-epicenter for development of the coastal area. It could also serve as the potential ground/site for action research linking with national research and extension organizations. We have suggested/recommended primarily 17 technologies which could be shared with a specific village community for their evaluation (Table 15). However, farmers have own idea about need-based technology but they are often lacking in opportunity-based technologies which the researchers may test through action research or small-scale demonstration before recommending scaling up. Moreover, in many cases local adjustment may be needed to adapt with the local conditions. Among the six studied villages applicable technology for each village is mentioned. It shows some of technology are appropriate across all coastal belt such as BARI developed homestead vegetable model or tower system vegetable production but few others are only for one or more specific village(s), such as ring setting at crop field for fish growth and development, it is applicable where tidal water enters crop field (i.e., non-polder area). Many other technologies may be shared with local residents described

in Table 13 and Table 14. The suggested technology options are not limited only to studied villages only, rather it may be applicable to similar other villages of coastal regions of Bangladesh and elsewhere.

Table15: Suggested technology options for Climate Smart Village of Southern Bangladesh

Technology options	Gaula	Biraljuri	Ruhitalbunia	Sripur	Chadipur	Buri Goalini
BARI Homestead vegetable model for saline and moist area including <i>Moringa</i> tree	Modified one as household need	Modified one as household need	Modified one as household need	Modified one as household need	Applicable	Applicable
Tower/sac system vegetable production	Applicable	Applicable	Applicable	Applicable	Applicable	Applicable
Ring setting at tidally flooded land for capturing visiting fish	Applicable	Applicable	Applicable	N/A (polder area)	N/A(polder area)	N/A(polder area)
Gher system cultivation for mixed agriculture (Fish+Rice+Vegetable)	Applicable	Applicable	Applicable	Applicable	Limited area	Limited area
Saline tolerant Boro rice cultivation (BRRI Dhan 47, 61, 67, 97,99, BINA Dhan 10)	BRRI Dhan 47, 97, 99	BRRI Dhan47, 97,99	BRRI Dhan 47, 61, 67, 97,99, BINA Dhan 10	BRRI Dhan 47, 61, 67, 97, 99, BINA Dhan 10	BRRI Dhan 47, 61, 67, 97, 99, BINA Dhan 10	BRRI Dhan 47, 61, 67, 97,99, BINA Dhan 10
Submergence tolerant Aman rice variety (BRRI Dhan 52)	Applicable	Applicable	Applicable	Applicable	Applicable	Applicable
Local aman rice + Fish	Selected area	Selected area	Selected area	Selected area	Selected area	Selected area
Cultivation of watermelon and other cucurbits by irrigating	Applicable	Applicable	Applicable	Applicable	Applicable	Applicable

non-saline surface water						
Zero/strip tillage maize cultivation-hybrids	Applicable	Applicable	Applicable	Applicable	Applicable	Applicable
Wheat cultivation (BARI Gom25, 26, 27, 29, 30)	Limited area	Limited area	Limited area	Limited area	Limited area	N/A
Summer Tomato on homestead or grafted summer tomato on wild brinjal (BARI hybrid tomato 4/ 4/ another hybrid)	Selected location	Selected location	Selected location	Selected location	Selected location	Selected location
Sesame cultivation (BARI Til 4/Local)	Selected location	Selected location	Selected location	Selected location	Selected location	N/A
Sunflower cultivation after rice (Hysun33)	Selected location	Selected location	Selected location	Selected location	Selected location	N/A
Mugbean(BA RI Mung 6) cultivation after T.aman rice	Tidal water free area	Tidal water free area	Tidal water free area	Tidal water free area	Selected location	N/A
Homestead fruit tree planting, management	Applicable	Applicable	Applicable	Applicable	Applicable	Applicable
Backyard pond management for fish cultivation	Applicable	Applicable	Applicable	Applicable	Applicable	Applicable
Cattle fattening (local/cross breed)	Applicable	Applicable	Applicable	Applicable	Applicable	N/A (under present condition)
Duck raring	Applicable	Applicable	Applicable	Applicable	Applicable	Do

5. Conclusion

Because of continuous global temperature rise, sea level is rising and heated environment is creating more cyclonic storm which is landing on the coastal area of Bangladesh resulting in devastating effect on agriculture, increase of salinity, housing, other infrastructures and overall livelihoods of mass people. Upstream rivers water flow (mainly Ganges-Padma-Gorai-Modhumati) in dry season decreased alarmingly causing increased salinity of water and soil. However, agricultural scientists, development workers and innovative farmers are trying to develop technologies and management options for adapting with the changing climatic hazard along with polder making in coastal zone.

6. Recommendation

- a. Climate smart agricultural (CSA) technologies on crop/fruit/vegetable, aquaculture, livestock those are already developed to be disseminated and deployed for increasing the agricultural production resulting in food and nutrition security of smallholders.
- b. For effective implementation of CSA it needs farmers (both men and women) hands-on training, information sharing on weather forecasting and tidal water status, supply of easy soft credit and ensuring availability of good seeds/seedlings/fertilizers/pesticides/fish fry/ livestock/ feeds/fodders and other logistics well-ahead of seasons.
- c. For sustainable development Climate-Smart Village (CSV) to be established by GO and NGOs in pilot basis in a participatory way with local farmers and residents.
- d. For sustaining agricultural production systems, live and properties polder height and strength to be increased as per need along with proper management of sluice gate for intrusion of non-saline water within the bunds and to save crop land from saline water intrusion.
- e. For area like Buri Goalini within the polder, monoculture of saline water shrimp (Bagda)/crab farming to be discouraged for restoring healthy natural ecosystem and production of different crops/trees/grass.
- f. Upstream rivers (Ganga-Padma-Gorai-Modhumati) water flow must be increased in dry season to save the ecosystems of Sunderbans, adjoining areas and to reduce salinity of southern regions.

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**Study of milk hygiene practice in dairy farms in Noakhali: A food safety
issue concern of Public Health**

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Milk hygiene practice in dairy farms in Noakhali: A food safety concern of Public Health

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Abstract

This study aimed to investigate milk hygiene practices, milk price fluctuations, and health hazard issues in dairy farms in the District of Noakhali of Bangladesh. A total of 20 dairy farms were surveyed to collect data on cattle size (7.75 ± 9.38), milk production (24.50 ± 23), and training on farming, vaccinations, hygiene practices, water sources, and health concerns of farm owners. The results showed that there were no significant differences in cattle size and milk production (P -value < 0.05). The majority of farmers did not receive training on farming and regular vaccinations for infectious diseases. Mastitis was found in only 30% of farms, indicating a lack of proper farm hygiene, likely due to knowledge deficiencies. . It was found that there was no relationship in chi-square test between hand wash of milker and mastitis ($p < 0.05$). Farm utensils were washed with detergent in 65% of farms. Approximately 55% of farmers used pond water as their primary source of water for their farms. No significant relationship was found between water supply and mastitis (P -value < 0.05). Some farm owners reported allergies and stomach issues, but most were not concerned about consuming milk. Weather conditions and market forces affected milk production and price. The study suggests that implementing preventative measures and proactive management strategies, such as cultivating high-yielding saline tolerant fodder, implementing effective milk preservation systems, providing consistent vaccine and quality water and proper training of the farmers can help minimize the impact of these challenges on dairy farming operations.

Keywords: Milk hygiene, price fluctuation, market forces, challenges

1. Introduction

Human beings rely on milk and dairy products as a significant source of essential nutrients (Otte, 2010). Meeting the escalating demand for milk, particularly in developing countries, is deemed significant and dairy farming is considered one of the crucial ways to fulfill this need. Dairy is also an important agricultural commodity in Asia, and the region accounts for more than 35 percent of global milk production (Developing Countries and the Global Dairy Sector Part I Global Overview PPLPI Working Paper No. 30 Vivien Knips). The dairy industry is of major importance in economic growth, with more than 150 million households globally involved in milk production. India is the world's largest milk producer, responsible for 22% of global production, followed by the United States of America, China, Pakistan, and Brazil (<https://www.fao.org/dairy-production-products/socio-economics/markets-and-trade/en/>). In Bangladesh, Cattle population is 24.856 million (2022-2023). In the study area it was 0.03852 million (Ref DLO, Noakhali 2021-2022). The dairy sector has a noteworthy impact on the economy of Bangladesh through multiple means such as lessening poverty, generating employment, enhancing food and nutrition, empowering women, and acquiring foreign exchange. The Department of Livestock Services (DLS) reports that the livestock sector accounts for 3.47% of Bangladesh's Gross Domestic Product (GDP).

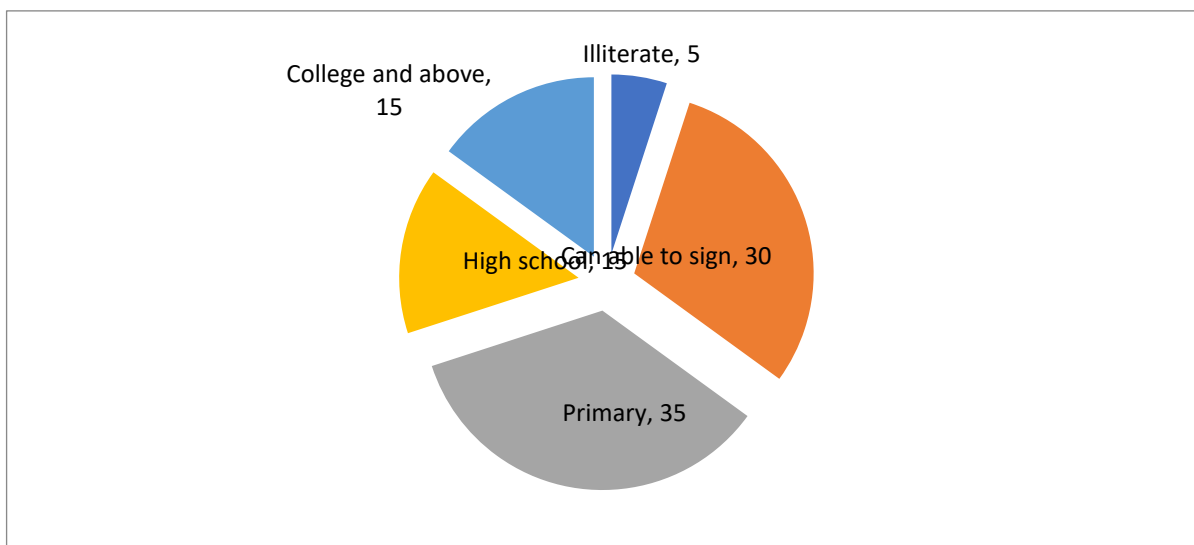
In Bangladesh, the increasing demand for animal protein, particularly dairy products, is driven by population growth, rapid urbanization, and rising income levels. However, the use of agrochemicals such as antibiotics and anti-parasitic drugs to improve milk production has led to the leakage of residues into the environment, negatively impacting natural processes, reducing biodiversity, and harming soil life (Groot & van't Hooft, 2016). Unregulated markets and a significant gap between rural and urban milk value chains have also led to farmers receiving unfair prices (Groot & van't Hooft, 2016). Unhygienic milk processing, serious adulteration of milk and milk products, and food safety issues further exacerbate the health risks associated with dairy farming. According to Staal et al. (2008), the growth of the dairy industry is influenced by various factors such as economic growth, resource value, consumer demand, public policies, interventions, and investment decisions. The increasing demand for animal products, particularly milk and milk products, in Bangladesh is being driven by population growth (1.8% annually), rapid urbanization (15% annually), and rising income levels. (Uddin et al., 2011).

To facilitate sustainable growth of the dairy sector, it is important to address food safety and quality issues along the dairy value chain, provide solutions to perishability, product inconsistency, and apply standards for milk quality and hygiene. Milk hygiene is the science concerned with production of clean wholesome milk which is free from bacteria or other disease causing organisms which may produce disease among consumers or cause the milk to spoil too quickly and to preserve in fresh state until it is taken from farm to consumer. On the other hand, public health is the art and science of preventing diseases, prolonging life and promoting human health and efficiency through organized community effort such as sanitation, vaccination, diseases treatment etc. Public health is nothing but human herd medicine. Environmental issues on dairy involve land and water scarcity, soil degradation, pollution of the waterways, greenhouse gas emissions from rumen fermentation, and waste management (Brown et al., 2022). It is crucial to investigate how climate and environmental factors impact milk quality in areas such as Noakhali, which is more vulnerable to natural calamities like cyclones and floods. Additionally, significant numbers of farmers in Noakhali rely on milk production as their main source of income. Hence, it is essential to understand how milk hygiene practices affect their livelihoods, and how public health concerns related to milk safety can impact the local economy.

Therefore, it is essential to address these problems to ensure sustainable growth of the dairy sector and improve the livelihoods of small-scale farmers.

2. Material and methods

A study was conducted using a cross-sectional design to collect data, with individual animal being the unit of sampling. The study gathered data from both rural and urban areas of Noakhali district, specifically from individual private dairy farms, using a standard questionnaire. The study population included 20 different types of farms including 160 cattle situated in various locations which were randomly selected. During the data collection and analysis process, coding was used, and SPSS was utilized. Descriptive statistics were mainly used, and a Chi-square test was performed to assess any association between current practices and risk factors. A p-value of less than 0.05 was considered significant in statistical terms.



3. Results and discussion

The study revealed several important findings related to the demographic characteristics of farmers in the area. Around 30 percent of farm owners were female, with only 10 percent acting as family heads, while the majority of farm owners (70 percent) were male. The literacy level of farmers was also explored, with 35 percent having primary school education, 30 percent being able to sign, and 15 percent having completed high school and college each, while 5 percent had no education.

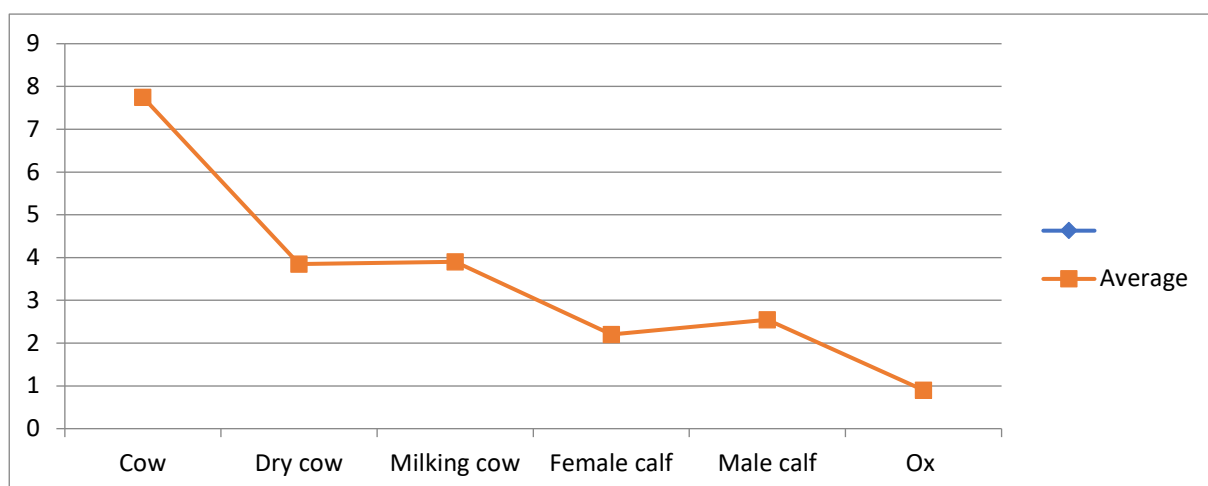
The vast majority of farmers (95 percent) were engaged in farm business, while a small percentage was housewives or involved in livestock farming. Furthermore, 95 percent of the farmers identified as Muslim. The average age of correspondents was found to be 42.6 ± 10 years, and they owned an average of 321 ± 55 decimal cultivable land and 73.6 ± 72 decimal homestead land.

The study also examined the financial situation of farmers, with the average monthly family income being BDT 45017 ± 42 and monthly expenditure being BDT 42400 ± 43 . The data revealed that there was no significant difference between monthly income and expenditure (p -value < 0.05). Additionally, 60 percent of farmers had taken loans, with an average loan amount of BDT 1, 44,500 from locally available financial institutions. On the other hand, only 45 percent of farmers were involved in savings, with an average of BDT 520, which was relatively very low in amount.

About 60 percent of farmers reported that at least one family member worked as an agricultural laborer in their local area, and most of their housing conditions were made of mud (60 percent), with 30 percent being semi-paka (Cementing) and only 5 percent fully paka. The majority of farmers (75 percent) used smartphones, indicating access to the internet and updated technology, which could potentially help them obtain information on new farming techniques and practices.

On the dairy farm, the average number of cattle was 7.75 ± 9 . This number was made up of dry cows (3.85 ± 5), milking cows (3.9 ± 4), female calves (2.2 ± 1), male calves (2.55 ± 3), and bulls (0.9 ± 0). The data showed that there were three main types of cattle breeds available: Shahiwal cross (15%), Holstein Friesian cross (35%), and Cross breed (50%). The majority of the animals were crossbreeds, due to the widespread use of artificial insemination services provided by the government, private entities (15% Lal teer), and NGOs, mostly Brac (85%).

The data also revealed that 65% of farmers had ensured AI services, while 35% had received irregular AI services. Cattle had been inseminated two to three times per reproduction cycle in 70% of cases. Additionally, approximately 35% of farmers faced difficulties in selling their milk in the local market.

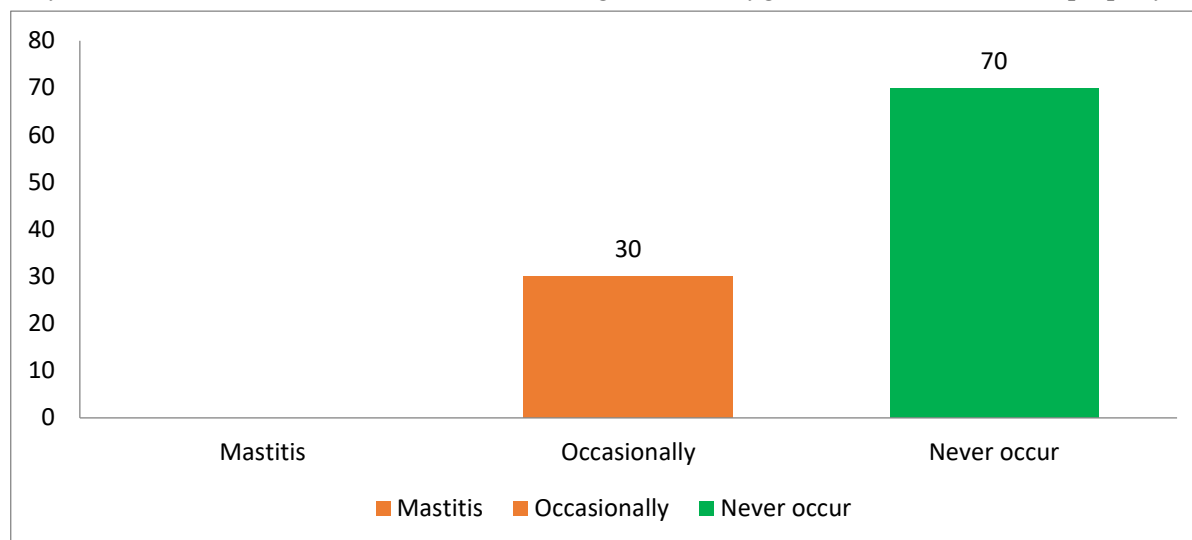


Some families consumed the milk themselves, while the rest was sold to local tea shops and sweetmeat shops.

A huge number of farmers (80%) did not receive any training from organizations on farming, mainly because the Upazila Livestock Office (ULO) was located too far away from their farms, with an average distance of 16 ± 6 kilometers. Instead, they learned farming techniques either from their neighbors or as part of their hereditary business. However, 10% of farmers received training from the ULO, while another 10% received training from locally available NGOs.

Seventy percent of farmers did not receive regular vaccinations for the prevention of infectious diseases. Instead, they commonly practiced vaccination against Foot and Mouth Diseases (FMD), Anthrax, Black Quarter (BQ), and Hemorrhagic Septicemia (HS) provided by government and private vaccinators, as veterinary doctors were unavailable in their area. Only one veterinarian worked in the government veterinary hospital, and farmers were compelled to seek veterinary services from quacks (25%) and trained primary health caregiver (45%). Due to the application of different vaccines, disease prevalence was not dominant in the research area.

Only 30% of farms had cases of mastitis, indicating that farm hygiene was not maintained properly,



likely due to knowledge deficiencies. Farm utensils washed with detergent in the farm level which was practiced 65% mostly but remaining 35 percent farm did not practice these process. Furthermore, the floor of the most cattle shed had cementing (90%) and also the gutter condition of farms better (70%). Data revealed that there was no significantly relationship between floor of cattle shed and mastitis (p-value 0.05). But Mastitis is an inflammatory condition that affects the mammary gland (breast) in mammals, including cows, goats and sheep. It is most commonly associated with cows in the dairy industry. Mastitis is caused by bacteria that infect the udder, leading to inflammation and swelling. The most common bacteria that cause mastitis in dairy cows are *Staphylococcus aureus* and *Streptococcus agalactiae*, among others. Prevention of mastitis involves good hygiene practices, such as keeping the milking environment clean, washing hands before milking, and properly cleaning and sanitizing equipment. It was found that there was no relationship in chi-square test between hand wash of milker and mastitis ($p < 0.05$). The prevalence of subclinical mastitis in smallholder dairy cows in Tanzania is high and that there are several risk factors associated with its occurrence. Improvements in milking hygiene practices, as well as better management of cow age, stage of lactation, and number of lactations, could help reduce the incidence of subclinical mastitis in smallholder dairy cows in Tanzania (Rotz et al., 2021). Additionally, maintaining a healthy and stress-free environment for the cows, as well as providing adequate nutrition and hydration, can help prevent mastitis. Regular veterinary checks and monitoring for early signs of mastitis are also important for preventing the spread of the infection and minimizing the impact on milk production. In order to reduce high prevalence of sub-clinical mastitis, smallholder farmers require to keep the udder clean, particularly in the wet season, improve floor conditions through regular cleaning of the floor or upgrade to concrete floor (Mureithi & Njuguna, 2016).

The average milk production of the farm was 24.50 ± 23 litre per farm and they sold the milk in retail and whole price were 68.50 ± 60 and 58.00 ± 60 respectively. Most of the farm milk let down at the same place and have no separate milking parlor (65%). There was a seasonal effect on milk production. Data showed that highest milk production happened from March to May (60%). Milk has been sold with plastic bottle (80%), in drum (15%) and Aluminium jar (5%). It was also observed that for maintain sanitation and hygiene the farm shed had been cleaned in an average 1.85 times in a day. It might show mastitis disease prevalence was comparatively lower in the Noakhali region.

Many farmers did not know about dry cow therapy (0.37 ± 0) which is very important for the keeping health the animals in the farm and for better performance in milk production (Bradley et al., 2015). The

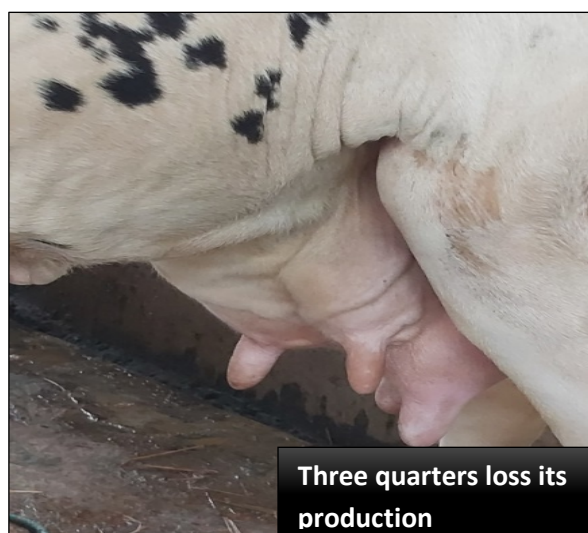
calf had received 95% of the colostrum milk, and the rest had been thrown. (Rotz et al., 2021) provide a comprehensive review of the nutrient and immunity transfer from cow to calf before and after calving. It emphasizes the significance of colostrum quality, timing of colostrum feeding, and quantity of colostrum fed for optimal calf health and immunity. It also discusses the factors that influence the nutrient and immunity transfer, such as cow nutrition and health, colostrum quality, and calf management practices. It concludes that providing high-quality colostrum to calves, within the first hours after birth, is essential for optimal growth and development of the calf.

Table 01: Purpose of dairy and dairy products uses

Items	Percentage (%)
Sale as liquid milk	75
Curd making	5
Sweetmeat making	5
Liquid milk and curd	5
Curd and sweetmeat	10

It was found that milk output rose between the months of March and May (by 60%), and between March and June (by 40%). Liquid milk made up the bulk of the milk's sales (75%), followed by curd (5%), sweetmeat (5%), liquid milk and curd (5%), and sweetmeat and curd (10%). Because milk is not very expensive in the local market, there is a chance to make milk by-products.

Ninety percent farmers applied deworming medicines to their animals in this study region. It indicates that farmers were very much aware of parasitic control in the farm which was augmenting milk production. The authors (Lawrence et al., 2020) focus on gastrointestinal worms in cattle and review recent research on parasite control strategies, including the use of targeted selective treatment, pasture management, and improved diagnostics. The authors highlight the need for a more integrated approach to parasite control that takes into account factors such as animal genetics, age, and nutrition, as well as environmental factors such as climate and grazing management.



When an establishment, such as a dairy farm, is established in a housing area, it is common for the neighbors to be concerned about the potential negative effects it may have on their quality of life. These concerns can include issues such as noise, odors, and increased traffic. However, there was no complaining from neighbors against the establishment of the dairy farm in the housing area indicates that the establishment has not caused any significant disruption or negative impact on the surrounding

community. This could be due to various reasons, such as the farm being located far enough from the residential area to minimize any disturbance, or the farm using modern technologies and practices to reduce the potential environmental impacts. It is also possible that the farm has established a good relationship with its neighbors and has addressed any concerns they may have had by taking appropriate measures to mitigate any negative effects. (Rotz et al., 2021) Such as improving manure management practices and using alternative feed sources to reduce methane emissions.

The majority of cow dung, approximately 85%, was utilized as fertilizer, while 5% was used for biogas production and another 5% was used as firewood. The remaining cow dung had no specific use. (Gupta et al., 2016) The paper emphasizes the importance of utilizing cow dung as a bio-resource for sustainable development in order to reduce the reliance on non-renewable energy sources and to promote environmental sustainability.

Approximately 55% of farmers used pond water as their primary source of water for their farms, while the remaining 45% relied on their own tube wells. Statistically no significant relationship between water supply and mastitis in the farms (p -value < 0.05). However, the use of pond water for cattle poses a significant risk, as it is often contaminated by various pathogens that can make the animals sick. (Smith, J., Johnson, R., & Garcia, 2021) Smith, in their article, supports this argument and emphasizes the potential for pond water to contain high levels of contaminants, including nutrients and sediments. The authors stress the importance of implementing proper pond management practices, such as regular monitoring and maintenance, to mitigate these risks and ensure the health and safety of the animals.

The sick cow's milk was provided to the maid servant 5% of the time, discarded 25% of the time, sold 20% of the time, and fed to the calf 50% of the time. The statistics showed that only 15% of farm owners were able to store milk separately, while 90% of farmers combined fresh milk with sick animal milk.

Table 02: Public health related issues

Types of stomach disorders	Percentage (%)
Stomach issues	30
Stomach pain	60
Dysentery	5
Indigestion	10
Allergy	15

Data in the table (02) showed that 15% of farm owners had allergies, 30% had stomach issues, and 85% had no concerns about allergies or stomach issues when consuming milk. 60% of farmers who reported stomach issues did so because they were in pain, 5% because they had dysentery, 10% because they had indigestion, and 25% because they had none at all. (Raturi et al., 2022) Raturi reported that different types of health issues occur especially in children about age of 5-10 ages. They suffer a lots of health issues such as weak eye sights, diarrhoea, stomach disorder, which is related with adulterated milk. Even in adults they also suffer from health issues, such as cardiac attack, gastrointestinal problems. Adulteration is harmful for human health cause gastrointestinal disease such as gastro intestinal problems diarrhoea etc. However, the analyzed data showed that there was no significant relationship between age, sex, education (p -vale < 0.05). Thirty percent goala showed skin problem on hand and only 35% percent goala washed their hand after using toilet. Bari studies were to improve the hygiene and sanitation of cows, to improve the cleanliness of farms and milkers' hands, to apply dry cow therapy, supplementing micronutrients and routine screening for Sub-Clinical Mastitis combined with taking intervention measures like isolation of cows or milking infected cows last, and proper treatment.

Also, full hand milking, complete milking, machine milking, and providing feed and water immediately after milking (Bari et al., 2022).

Data revealed that farmers sold milk 55% and discard rest 45 milk while treating the animals with antibiotics. The use of antibiotics in cattle during milking can have various effects on milk quality and safety, as well as on human health. Antibiotics can leave residues in milk, which can be harmful to human health and can lead to antibiotic resistance. Residues can occur if milk from treated cows is not properly discarded during the withdrawal period, which is the time during which the animal is not milked after treatment to allow the antibiotics to clear from its system. Antimicrobial resistance in East Africa dairy production" by Kimera and Mdegela (2017) provides an overview of the problem of antimicrobial resistance (AMR) in dairy production in East Africa. The authors discuss the drivers of AMR in this region, including the misuse and overuse of antibiotics in animal production, as well as poor sanitation and hygiene practices. They also highlight the potential public health implications of AMR, such as the increased risk of infections in humans that are difficult to treat.

Table 03: Nutritional status of farmers

Nutrition issues	Minimum	Maximum	Average	Std. Deviation
Meat eaten per week	0	6	2.00	1.298
Fish eaten weekly	1	7	4.20	1.399
Egg eaten per week	0	7	3.25	1.943
Fruit eaten per week	0	7	2.65	1.927
Milk drinking per week	0	7	6.15	2.134

According to the table, one farmer ate two days of meat, four days of fish, three days of eggs and fruit and six days of milk per week. The data showed that a particular farmer consumed a balanced diet consisting of meat, fish, eggs, fruit, and milk. This balanced diet could be indicative of good nutritional health for the farmer and possibly their family. Consuming a diverse range of foods from different food groups is essential for maintaining good health and preventing nutrient deficiencies. Meat is a good source of protein, which is essential for building and repairing tissues, while fish is rich in omega-3 fatty acids that are beneficial for heart health. Eggs are an excellent source of protein and several essential vitamins and minerals, including vitamin D, vitamin B12, and choline. Fruits are rich in vitamins, minerals, fiber, and antioxidants, while milk is an excellent source of calcium, which is essential for building strong bones and teeth. By consuming a variety of foods from different food groups, the farmer in question is likely meeting their nutritional needs, and this may indicate that the dairy farm owner has maintained a healthy and balanced diet for their family.

3.1. Reasons for price fluctuation of milk

Good nutrition, access to excess green grass, and favorable conditions can increase milk production in cows. On the other hand, inadequate nutrition or illness in cows can lead to a decrease in milk production. Weather conditions and food availability during the rainy season can also limit grass production, affecting milk production. Market forces, represented by the bazar syndicate, can affect milk demand and price, ultimately influencing milk production. (Jones, S., Smith, M., & Patel, 2022) The authors agreed with these factors. They found that changes in milk production, weather patterns, and international trade are among the key drivers of milk price volatility. They also found that government policies, such as subsidies and trade agreements, can have a significant impact on milk prices. Additionally, market competition and the concentration of buyers and sellers in the dairy industry can affect milk prices. The study highlights the importance of understanding the complex and

interrelated factors that influence milk prices. By identifying the drivers of price volatility, policymakers and industry stakeholders can better anticipate and manage the risks associated with milk production and marketing. The region where cows are reared can also impact milk production due to variations in resources and conditions. Enhancing milk production can result in a surplus of milk, leading to fewer consumers. Other factors such as insufficient fodder cultivation, high feed costs, and lack of demand from sweetmeat shoppers can negatively impact milk production. Additionally, milk production can be hindered by the unavailability of pikers and goalas.

3.2. Stabilize the price of milk to avoid fluctuations

Establishing a sustainable marketing system with permanent milk suppliers is essential to ensure a consistent supply of milk. This can involve strategies such as cultivating green grass and high-yielding fodder for cows, as well as implementing effective milk preservation systems. To counter market forces that negatively impact milk production, such as the bazar syndicate, government or privately-owned milk production facilities may need to be established. Collective selling of milk can also be beneficial, as it can enhance the bargaining power of the sellers. The establishment of a chilling plant and milk collection center can also improve milk production efficiency and quality (Brown, K., Davis, J., & Lee, 2021). Brown supports this view and advocates for marketing cooperatives as a strategy for stabilizing milk prices. These cooperatives allow farmers to pool their resources and negotiate better prices with processors and retailers. The authors suggest that this approach can benefit small farmers and give them more bargaining power. However, they also note that marketing cooperatives may not be suitable for all farmers and may require significant investment of time and resources. Increasing the number of goalas can also help meet the demand for milk. Overall, focusing on improving milk quality and consistency can satisfy the needs of large sweetmeat shops and other consumers.

3.3. Challenges in dairy farm

Dairy farming can be a complex and challenging enterprise, and there are many issues that farmers may face. One common challenge is not receiving a proper price for milk, which can impact the profitability of the operation. Additionally, veterinary services may be irregular or lacking, which can lead to animal sickness and disease outbreaks. Ensuring timely vaccines and treatments is important for maintaining herd health. Furthermore, a lack of veterinary doctors and training can make it difficult to address health issues and implement preventative measures. Poor housing systems can also contribute to animal health problems and reduced milk production. Disease outbreaks, such as FMD, LSD, BQ, external insects, naval ill, and diarrhea, can be difficult to prevent and control. In Bangladesh, an outbreak of an unknown syndrome with nodular skin lesions was reported by local veterinary services authority in mid-2019 in commercial and backyard cattle population in some locations (Anwara, Karnaphuli and Patiya) of Chattogram district (Hasib et al., 2021)

High feed costs can also impact the profitability of the operation, and the lack of experienced workers, such as Pikers and AI technicians, can make it difficult to manage the herd efficiently. Additionally, the unavailability of high-yielding fodder grass, coupled with the lack of green grass, can lead to feed shortages and higher costs. In livestock farming, optimum production may not be achieved without ensuring abundant supply of feeds and fodder to the animals. (Koura et al., 2021) that, feeds and fodder are considered as the biggest problem for obtaining optimum return from livestock and their development in the country. Sarker reported that the majority of households feed their livestock with crop residues, followed by grasses and leaves from trees. The study found that fodder availability was a significant challenge in the region, and farmers faced difficulty in obtaining sufficient amounts of feed throughout the year (Sarker et al., 2018). Breeding problems, such as delayed heat and difficulty conceiving, can lead to reduced milk production and higher costs. Inconsistent vaccine supplies and

poor-quality water can also impact animal health and milk production. Cows allowed drinking from surface water sources such as ponds and creeks are potentially at risk from bacteria and cropland runoff containing pesticides. Often, it is best to fence off these areas for better cattle health (Kononoff & Clark, 2017). AI may be necessary for breeding, but it can require additional resources per cattle, further impacting costs.

4. Conclusion

To sum up, dairy farming can be a difficult and complex business with several obstacles that farmers may encounter. Nevertheless, there are methods to tackle these obstacles by implementing preventative measures and proactive management strategies. It is crucial for the government to offer support to farmers by providing veterinary medical services, soft loans, training programs, and other incentives. Additionally, educating dairy farmers and paravets about the negative consequences of unnecessary use of antibiotics in dairy animals is essential. These initiatives can help to enhance the overall productivity and profitability of dairy farming operations while ensuring the well-being of livestock. A collaborative approach between the government and farmers can create a sustainable and thriving dairy industry.

5. Conflict of interest

There are no disclosures to make

6. Recommendation

- There should be an increase in veterinary medical services to ensure prompt and efficient care for livestock.
- The government can provide soft loans with low interest rates to help farmers access the necessary financial resources for the growth and development of their farms.
- Training programs should be offered to improve the knowledge and skills of farmers in various aspects of dairy farming.
- The government can also ensure that vaccines are made available in a timely manner to prevent livestock diseases.
- The establishment of milk processing plants in the area can provide an opportunity for farmers to sell their milk at higher prices.
- Government services should be made free to ensure accessibility and affordability for all poor farmers.
- To improve breeding practices, adaptable and improved variety semen supply can be made available to farmers. Incentives from the government can also be offered to encourage farmers to improve their production practices.
- To reduce the price of livestock inputs, the government can control the price of livestock feed, and livestock medicines.
- The government can provide subsidies on electricity bills in livestock farms to ensure uninterrupted electricity supply. The provision of HYV fodder cutting and seed can also be made available to farmers to improve the quality of feed for their livestock.
- Provide incentives for local farmers as 95% milk produced from local dairy farms.

7. Acknowledgements

The Centre for Strategic and Peace Studies (CSPS), a think tank established in 1999, deserves gratitude from the authors for its funding support. The organization's primary responsibility is to carry out empirical and policy research on strategic and peace-related matters, as well as to host seminars on relevant topics, with participation from national-level dignitaries, academicians, and researchers from various countries. Additionally, the authors express their thanks to Md. Rasel Miah and Hasina Akter for their assistance in collecting data for the research.

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Poverty Alleviation, Rural Development and Reducing Social Inequality: Experiences of a Pioneering Rural Development Institution in Bangladesh

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Action Research Experiences of BARD in Rural Poverty Alleviation and Reducing Social Inequality

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Abstract

In this review paper, rural development models and approaches developed by BARD through action research for reducing social inequality from 60s to till today have been pondered and at the same time current action research activities of BARD also been highlighted briefly. The institutions like LGED, TTDC, TIP and Two-tier Co-operatives developed from Comilla Approach to Rural Development have been highlighted in this paper. It has been discussed thoroughly the transformation process of SFDF from SFDP. All the on-going action research or projects of BARD also been reflected in this research paper. Lessons learnt from the rural development models, approaches and on-going experimentations have been highlighted. The outcomes of the rural development models, approaches and findings of different on-going action research and experimentations addressed some of the most vital SDGs. Some policy recommendations have been made in this paper as: (i) The theory of integration with people's participation and bottom-up planning and implementation should be considered in developing any rural development model for reducing social inequality; (ii) The policy planners, government and the research organizations should put due emphasis on rural development experimentations regarding the problem of the tomorrow's poor people along with the current poor people; (iii) Emphasis should be given for developing rural development model that can create an organizational structure and institutional culture; (iv) In developing any rural development model, provision should be kept for creating strong human capital base; (v) Leadership component should be included in rural development related experimentations; (vi) Provision should be kept in developing rural development model for building strong need-based organizations at the village level; (vii) Emphasis should be given on such rural development experimentation and developing model which could be created huge employment opportunities at the village level; and (viii) Necessary experimentations should be undertaken at the village level for improving home management skill of the women.

1. Introduction

Action research is a research method that aims to simultaneously investigate and solve an issue. In other words, as its name suggests, action research conducts research and takes action at the same time. Action research is often used in the social sciences. Due to the nature of the research, it is also sometimes called a **cycle of action or a cycle of inquiry**.



Source: <https://www.scribbr.com/methodology/action-research/>

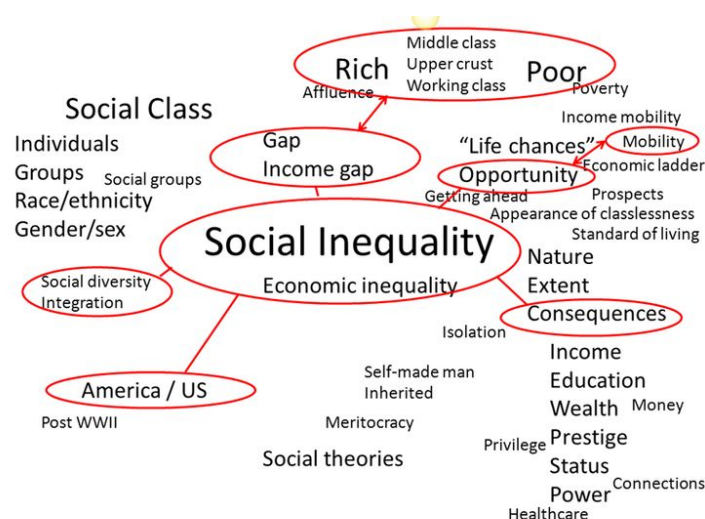
There are 2 common types of action research: participatory action research and practical action research. Participatory action research emphasizes that participants should be members of the community being studied, empowering those directly affected by outcomes of said research. In this method, participants are effectively co-researchers, with their lived experiences considered formative to the research process. Practical action research focuses more on how research is conducted and is designed to address and solve specific issues. (<https://www.scribbr.com/methodology/action-research/>) (Published on January 27, 2023 by [Tegan George](#). Revised on June 22, 2023).

Rural poverty refers to [poverty](#) in [rural areas](#), including factors of [rural society](#), [rural economy](#), and [political](#) systems that give rise to the poverty found there.^[1] Rural areas, because of their spread-out populations, typically have less well maintained infrastructure and a harder time accessing markets, which tend to be concentrated in population centers. Rural communities also face disadvantages in terms of legal and social protections, with women and marginalized communities frequently having hard times accessing land, education and other support systems that help with economic development. Several policies have been tested in both developing and developed economies, including rural electrification and access to other technologies such as internet, [gender parity](#), and improved access to credit and income (Janvry, et al., 2002).

Eradicating rural poverty through effective policies and economic growth is a continuing difficulty for the international community (Jazaïry, Idriss, 1992), (Otsuka, Keijiro. 2009). According to the [Food and Agriculture Organization](#), three quarters of those in poverty are in rural areas, most of whom are [smallholders](#) or [agricultural workers](#) whose livelihoods are heavily dependent on agriculture (www.fao.org. Retrieved October 10, 2021).

Social inequality means individuals in a society that do not have equal social status. The unequal sharing of scarce resources and social rewards. Social inequality occurs when resources in a given society are

distributed unevenly. Social inequality is linked to [economic inequality](#), usually described on the basis of the [unequal distribution of income](#) or [wealth](#). ‘Notwithstanding the government of Bangladesh clear recognition and commitment towards reduction, poverty and social inequality continue to pose and prompt formidable challenges for the country—notably the high level of rural–urban disparity in terms of income, education, gender, health facilities, land ownership and social opportunities’ (Islam, et al., 2020).



Source: <https://www.pinterest.com/pin/401946335465023011/>

Bangladesh Academy for Rural Development (BARD) which was established in 1959. It was established to train government officials and representatives of the local government and village organizations on various subjects relating to reducing social inequality. The founding Chief Executive of BARD was Dr Akhter Hameed Khan, an internationally renowned social scientist. It is an autonomous institution governed by a Board of Governors of which the honourable Minister for Local Government, Rural Development and Cooperatives is the Chairperson. Administratively, it functions as an affiliated institute of Rural Development and Cooperative Division, the Ministry of Local Government, Rural Development and Cooperatives. The Academy is famous for its evolved model “Comilla Approach to Rural Development” through action research for rural poverty alleviation and reducing social inequality in 60s which is well-known at home and abroad (Quader et al., 2022).

In 70s, for financial inclusion of the poorest of the poor in the rural areas BARD conducted another action research titled “Small Farmers and Landless Laborers Development Project (SFDP)” for more than 20 years upto the late 1990s. SFDP was the pioneer programme in introducing collateral-free micro credit amongst the poorest of the poor segment of people in rural Bangladesh for reducing social inequality. Later on, this project experimentation turned in to a ‘Foundation’ which is called “Small Farmers Development Foundation” (SFDF)

Based on experiences of SFDP, BARD conducted another action research and piloted the same in the name of “Total Village Development Program” (TVDP) to address the limitations of SFDP. The TVDP was renamed later on as the “Comprehensive Village Development Program” (CVDP) which is still piloting all over the country (Rahman and Roy, 2004).

So far the BARD has conducted more than 70 action research projects on various aspects of rural development for poverty alleviation and reducing social inequality. Some recent initiatives on poverty alleviation, establishing village-based strong institution, reducing social crime, reducing social inequality and ensuring sustainable rural development are: Women’s Education, Income and Nutrition

Improvement Project (WEINIP); Rural Livelihood Improvement through Village Based Organizations and Union Parishad; E-Parishad for Better Service Delivery in Rural Areas; and Improving Livelihood of Rural People of Lalmai-Mainamati Hill Areas of Cumilla through Integrated Agricultural Farming. (Quader et al., 2022). In this study it was tried to highlight the philosophy and crystal insights of BARD's six decades experiences on action research towards poverty alleviation and building strong institutions for sustainable rural development, ensuring social justice and reducing social inequality. Based on the findings/outcomes of this research the policy planners will be able to suggest for building appropriate approaches of development for Bangladesh to address the important SDGs like no poverty; zero hunger; gender equality; reduced inequality; sustainable consumption; peace, justice and strong institution (especially in the rural areas of Bangladesh). The study tried to pin-point some specific issues as mentioned above with the following objectives.

2. Objectives of the study

The broad objective of the study was to review the BARD's rural development models, approaches and activities related to poverty alleviation, reducing social inequality, institution building and ensuring social justice. The specific objectives were as follows:

To highlight the philosophy and ultimate goals of different rural development models and approaches developed by BARD through action research for reducing social inequality;

To find out the lessons learnt from different rural development models, approaches and action research for reducing social inequality accomplished by BARD; and

To blend the outcomes of different rural development models, approaches and action research of BARD for reducing social inequality and link those with the important SDGs.

3. Methods of study

The study was conducted through reviewing secondary data and information available in different books, journals, annual reports, articles published in newspapers, newsletters, bulletins, experiences of the author etc. All the collected data were compiled literally and analyzed from the research point of view and finally presented in the report chronologically.

4. Results and Discussion

4.1. Review of Rural Development Models for reducing social inequality, Approaches and On-going Action Research of BARD

BARD was established in 1959 and Comilla Model of Rural Development was developed in 1960s which was the first outcome of the action research of BARD. Later on, BARD has developed some other rural development models/institutions for reducing social inequality from its experimentations (Sattar, M. G., 1996). Presently BARD has been implementing different action research/experimentations for reducing social inequality under the fund of Annual Development Programme (ADP) of the Government of Bangladesh and at the same times some action research from its own revenue budget. The core aspects of different rural development models, approaches and experimentations have been highlighted in this chapter.

4.2. Comilla Model of Rural Development for reducing social inequality

It was tried to highlight some of the important dimensions of the model for better understanding the importance and usefulness of the model to the mass people. These are:

how the model was developed;

what were the basic assumptions of the model;
which viable programmes and institutions have been developed;
how effective was the model in tackling the core problems of rural development for reducing social inequality; and
Types of institutions developed through the model.

4.2.1. How the model was developed

The Comilla Model or Comilla Approach to Rural Development was evolved out of a series of experimental or pilot projects conducted by BARD in Comilla Kotwali Thana (now Upazila) the “laboratory area” of the Academy. The model was the outcome of a search for innovation in rural development for reducing social inequality in a low-income densely populated agrarian society. Several elements were combined and steps involved in the evolution of Comilla Model.

The first step taken by the government in setting up the pilot projects was the establishment of a training and research institution-the BARD. The second step involved was the affiliation of a laboratory area to this institution. The purpose of the laboratory areas was to carry on survey research and organize action-research or pilot projects. The third step and a very important one, was thorough study of the laboratory area and intensive consultation with villagers regarding their problems and their views about the solution of those problems. The fourth step was close collaboration with the national planning commission which made and evaluated policies and prescribed priorities in respect of plan and projects. The fifth step was continuous evaluation and documentation of the pilot projects, not only to determine their progress but also to discover their weakness and revise them as and where necessary. The sixth step was assisting the government agencies in the multiplication of the model. These are the vital elements the combination of which led to development and multiplication of the Comilla Model (Khan, A.R., 1979).

4.2.2. Basic assumptions of the model

There were certain important basic assumptions worked behind the development of the Comilla Model. These were as follows:

The villagers have the best understanding of the problems of rural life and rural situation. So the problems of rural development should be approached from their own point of view;

The villagers are capable of bringing about changes in their conditions. Given the means for development, the villagers themselves would be in a position to initiate the process of changes;

Rural development is undoubtedly much wider and broader in scope and dimension than agricultural development. But agricultural development should be made an essential step in initiating a broader rural development process;

Village should be approached as a unit and recognized as the starting point for the process of modernization; and

Training, research and demonstration are essential in promoting rural development, and these should be dynamically integrated into the life of the rural community (Quddus, 1996, p.107).

4.2.3. Viable programmes and institutions developed

The Comilla experiment produced models of several viable programmes and institutions in rural development for reducing social inequality. Four of the models (also termed as components of Comilla Approach to Rural Development) were adopted for nationwide replication. These four national programmes are:

4.2.4. Thana Training and Development Centre (TTDC)

Established a training and development center (TTDC) in every thana (now *Upazila*). “The concept of a TTDC emphasized the need, for the sake of development, of complete coordination between the nation building departments and between these departments and the institutions and leaders of local government” (Khan: 1983, p.123). “The assumptions were that the people should be mobilized through their elected leaders (of local councils); that the officers should coordinate departmental activities with each other as well as with the councilors” (Khan: 1983, p.149). “The Thana Centre was to be the focus not only of planning and coordination but also of training. Special halls and classrooms were added and officers were encouraged to teach” (Khan: 1983, p.149). “All services and supplies and experts were to be located in the same building for the convenience of the people” (Khan: 1983, p.124).

4.2.5. Rural Works Programme (RWP)

A road-drainage embankment works programme in every thana. “The RWP was an attempt to tackle the fundamental problems-construction of network of roads, drainage channels and embankments and provision of employment during the dry idle months to the landless laborer’s” (Khan: 1983, p.124). “Rural drainage and embankment are the infrastructure of rural development for reducing social inequality. Without link-roads without good drainage and without protective embankments there cannot be much agricultural development. And without employment to the rapidly increasing landless villager, no government can hope for stability” (Khan: 1983, p.124). “The Works Programme proposed to build this infrastructure in partnership with the local councils. The Road Engineers and WAPDA Engineers were urged to give technical guidance and encourage and rain the people to help themselves without contractors” (Khan: 1983, p.124-5).

4.2.6. Thana Irrigation Programme (TIP)

A decentralized, small-scale irrigation programme in every thana: “The TIP carried the road and flood control works one step further. It created the third infrastructure irrigation facilities during the dry periods” (Khan: 1983, p.125). “Water, like soil and sunshine is East Pakistan’s (now Bangladesh) great resource. But up till 1960 it was scarcely used during winter” (Khan: 1983, p.124-5). Ninety three percent of the land lay fallow from December to May. Water was flowing in hundreds of rivers and *khals*. There were immense reservoirs of underground water. “The TIP aimed to use these resources to the fullest extent by mobilizing the farmers. They were to search for the water source and organize irrigation groups themselves. The EPADC (now BADC) was to locate the workshop at each thana center. Here the drivers were to be trained, mechanics maintained and pumps and fuels stored” (Khan: 1983, p.125). “Where surface water was of not available tube wells were to be sunk. The model in this case was not to be an expensive contractor’s tube-well, but the cheap ‘people’s tube-well’, spectacularly developed in West Pakistan (now Pakistan) and China” (Khan: 1983, p.125). “The EPADC was to assemble rigs and train the drillers, so that each thana workshop may have ten drilling rigs. Ten drilling rigs can sink at least five tube-wells each month or sixty tube-wells in a year. Thus in five years, three hundred tube-wells may be sunk in one thana” (Khan: 1983, p.126).

4.2.7. Two-tier Co-operatives

The two-tier cooperative system was “an attempt to organize the small farmers. They form the overwhelming majority. They are, at preset, grossly exploited by a vicious system of moneylending and trade.... They cannot modernize their farming methods or use machines individually.....It can replace moneylender and it can provide the bond for joint action. It could be the trade union of the small farmer” (Khan: 1983, p.126-7). “The cooperatives promote accumulation of self-owned capital through thrift and they promote managerial and technical skill through training. Their ultimate aim is self-financing

and self-management” (Khan: 1983, p.127). The two-tier cooperative system with its close contact between the government experts and village managers and model farmers has proved a very effective instrument of agricultural extension.

4.2.8. How effective was the model in tackling the core problems of reducing social inequality

The model offers an effective methodology of attacking some of the root causes of rural poverty, social inequality and backward-ness. The approach has made significant contributions towards national development in Bangladesh. The Comilla experiment has also generated many new ideas and methods which have provided a basis for formulating other national programmes. The national programme in women’s development introduced by the BRDB is based on the model evolved through the Comilla experiment. The Comilla model has ushered in a new era of reducing social inequality in Bangladesh by replacing the old colonial approach to “development through officers”. The model has evolved a combination of training knowledge-communications system which is essential for the development of human resources. The Comilla experiment has generated a set of principles and tested methodologies which can be used in formulating and operating any programme in rural development for reducing social inequality. In fact, many agencies and organisations in Bangladesh have adopted these methodologies in their programmes (Quddus, 1996, pp.114-118).

4.2.9. Types of institutions developed through the model

The four components of Comilla Model have now become four different government departments. Two Tier Cooperatives have turned into Bangladesh Rural Development Board (BRDB), Rural Works Programme (RWP) has turned into the Local Government Engineering Department (LGED), Thana Irrigation Programme (TIP) has been integrated with Bangladesh Agriculture Development Corporation (BADC) and Thana Training and Development Centre (TTDC) has been turned into *Upazila* complex (Obaidullah, A.K.M., 1995).

4.2.10. Concluding remarks about the model

The Comilla Model of rural development was developed in the sixties. It has worked well and showed spectacular results. But questions may be raised whether the model developed in the sixties is relevant for contemporary Bangladesh, the SDGs, whether this is effective enough to deal with the emerging socioeconomic problems, whether it fits into the current perspectives of national planning through addressing the relevant SDGs. To be effective a rural development strategy for reducing social inequality should comprise certain essential elements. It may be examined whether the Comilla model or approach to rural development for reducing social inequality incorporates these essential elements. These elements are people’s participation in the development process, decentralized decision-making, institution building and development of people’s organization, development of human resources and skills, internalization of innovations, mobilization and use of local resources, linkages of people’s organizations with public sector and other institution, production and employment generation and sustainability of development.

The Comilla Approach to rural development never claims that it is a panacea of all the socio-economic ills prevailing in the rural society. Despite its deficiencies or shortfalls the Comilla cooperative system has by now become well-known to many Bangladesh farmers and is considered by them to be a workable form of organization for the adoption of new agricultural technology (Bose, 1974).

It can be said that the Comilla Model contain all these elements. The results and performance of model are well documented and well researched, can substantiate this observation. As one insider has pointed out, “The greatest testimony of the viability of a concept is its results. In that analysis the Comilla

Approach has still no peer”. Any careful observer will come to the conclusion that this is not an exaggeration. Therefore, the model developed in the sixties is relevant for contemporary Bangladesh, the SDGs, this is effective enough to deal with the emerging socioeconomic problems, and it fits into the current perspectives of national planning through addressing the relevant SDGs. In other words it can be said that Comilla Model directly or indirectly addressed the SDG1 (No poverty), SDG2 (Zero hunger), SDG8 (Decent work and economic growth), part of SDG9 (Industry, innovation and infrastructure), part of SDG11 (Sustainable cities and communities), and part of SDG16 (Peace, justice and strong institution).

4.2. Small Farmers & Landless Laborers Development Project (SFDP)

4.2.1. Genesis of the project

BARD experimented two other projects, namely *Small Farmers & Landless Laborers Development Program (SFDP)* and *Comprehensive Village Development Programme (CVDP)* in the mid-seventies and early eighties. The latter one is now being implemented by four organizations in one *Upazila* of each Sixty-Four Districts while SFDP is transformed as “Small Farmers Development Foundation (SFDF)”, a self-sustaining organization.

Small Farmers Development Project has the distinction of being the pioneer among the target group-oriented projects for the poor and disadvantaged for reducing social inequality in Bangladesh. It was conceived at the time when the problems of landlessness and marginalization just began to attract the attention of planners and policy makers. SFDP started its journey in seventies as an Action Research Project of FAO for reducing social inequality. FAO conducted a survey ‘Asian Survey on Agrarian Reforms and Rural Development (ASARRD) in eight Asian Countries (Bangladesh, India, Indonesia, Korea, Nepal, Philippines, Sri Lanka and Thailand) in 1974. Commencement of the SFDP-1976 (M/O LGRD & C) as an action research project with collateral free micro credit for small farmers (SF) and landless laborer’s (LL) for reducing social inequality (Rahman and Choudhury, 2012).

4.2.2. Objective of the project

The immediate objective of the project was to increase production, employment and income of the Small Farmers and Landless Labourers through the formation of small homogeneous group.

The ultimate objective was to develop a sustainable and replicable institutional framework for the development of SF and LL for reducing social inequality through utilization of support services of existing GoB departments mainly credit from nationalized banks.

4.2.3. Implementation strategies

Organize the male/female of the small farmers (having 0.51-1.50 acres of cultivable land) and landless Labourers (having less than 0.51 acres of cultivable land) families into informal groups (5-10 members) (appropriate size 7-8 members);

Provide collateral free credit to the group members through the nationalized banks (JB/KB) (Observation period-3 months, 1st loan Tk. 5000) (repayment period 12-18 months) for undertaking income generating activities;

motivate the group members to accumulate their own savings through small deposits;

human resource development (training) (Group dynamics & IGAs); and

motivation for social development activities (sending children in school, participate in immunization programme, taking low-cost nutritional food etc.).

4.2.4. Financial management

The project was operating under ADP. UNDP provided technical assistance up to 1991 and United Nation Capital Development Fund (UNCDF) provided credit fund up to June 1999. GoB –manpower and other operational costs.

4.2.5. Lessons learnt

SFDP experience shows that the poor people can improve their socio-economic conditions if they are given small credit. Now at government and non-government levels, many organizations including Grameen Bank are implementing micro-credit programmes for alleviating poverty and reducing social inequality of the country.

SFDP first involves Janata Bank in providing collateral free microcredit to the poor. Gathering experience from SFDP and Janata Bank many commercial banks including Bangladesh *Krishi* Bank of the country have been undertaken many collateral free microcredit programmes for the poor for reducing social inequality.

Village *Mahajans* (rural money lender) are the main source of credit. The poor people generally would take credit with high interest. When SFDP becomes a source of microcredit for the poor they began to receive small credit with less interest from it. As a result, dependency of the poor on village *Mahajans* is decreasing.

Quality of lives of many beneficiaries of SFDP has been improved due to increase their income.

Before undertaking SFDP by the Academy the “Pauperization” trend in the rural areas was that the landless people were becoming more destitute and marginal farmers were becoming landless. When the landless and marginal farmers started to involve in the SFDP activities from then this trend has been decreasing.

It is also learnt that when the poor people default loan of SFDP it does not lose all principal money. The organization can lose at best interest of principal money but when the rich people default loan of a commercial bank it loses both principal money and interest.

Poor people, male and female, are capable in using the support and services of banks if they are given guidance and cooperation.

In comparison to males, the females are more efficient in utilization and repayment of credit and also formation of own capital through thrift deposits (Uddin, M.M., 1990).

4.2.6. Transformation of SFDP to SFDF

A Task Force was constituted by the RDCD to evaluate the performance of the project and formulate recommendations for future programming of the project in 2003. The terms of reference (TOR) of the task force were:

To examine management and financial aspects of the projects;

To evaluate impact of the project activities along with financial viability; and

To suggest appropriate organizational structures after its completion.

The Task Force having gone through the findings of various evaluation studies and having made intensive field visits to project areas was convinced about the project and presented the facts as follows:

The SFDP is an effective and viable model for poverty alleviations.

Its specialty lays in the fact it addresses the problem of the tomorrow's poor the small and marginal farmers along with the landless.

The SFDP has also created an organizational structure and institutional culture which could be the basis for a permanent organization.

The SFDP has created a strong human capital base which can be used effectively for poverty alleviation.

BARD being essentially a Research and Training Institution cannot indefinitely continue to implement SFDP.

It is in the above context that the Task Force recommends that SFDP can be converted into a foundation named "*SMALL FARMERS DEVELOPMENT FOUNDATION*" (SFDF).

Based on the recommendations of the task force SFDP formed as Foundation in 27 July 2005 (under Company Act 1913, amended in 1994) and started its activity in February 2006. The mission of SFDF was that it will be the Company not for profit. The activities of SFDF concentrated on poverty alleviation and rural development for reducing social inequality. SFDF is directly addressing the SDG1 (No poverty), SDG2 (Zero hunger) and part of SDG8 (Decent work and economic growth).

4.3. Comprehensive Village Development Programme

4.3.1. Genesis of the project

Considering the aspects of heterogeneity of rural people BARD undertook a rural development project for reducing social inequality in 1975 in the name of Total Village Development Programme (TVDP), which later on was renamed as Comprehensive Village Development Programme (CVDP). The view of the project was to develop a package programme for an integrated and total development of the villages by bringing all classes of people within one institutional framework. The project aimed at all round development of the heterogeneous rural people for reducing social inequality. The purpose of the project was to make better the socioeconomic condition of the rural people by mobilizing all the available local resources (Islam, 2007).

4.3.2. Evolution of CVDP

BARD implemented TVDP from 1975 to 1988 with its scanty amount of fund in a limited scale in the Comilla District for reducing social inequality. In the context of need for reorganization and readjustment of the existing experimental projects, reformulation of the TVDP felt necessary. The reformulated programme is the Comprehensive Village Development Programme (CVDP), which was done in 1988 (Karim, 1992). At this stage, the project convinced and attracted government support by its explicit and remarkable output. The implementation period of the project from 1989 to 1991 may be called as first phase of CVDP, which functioned under the Third Five Year Plan of Bangladesh. The second phase of the project was started in July 1991 and ended in June 1996. In this phase the project of BARD part began to implement in four *Upazilas* of three districts at 40 villages. The Rural Development Academy (RDA), Bogra also started to implement the same project at another 40 villages. The third phase of the project called demonstration phase, which was started in July 1999 and ended on 30 June 2004. Comprehensive Village Development Project is the first grass-root and participatory form of organization for rural development in Bangladesh (Hasan, M.S., 1991). This programme is now being replicated as 'National Rural Development Model'. Bangladesh Academy for Rural Development (BARD), Rural Development Academy Bogra (RDA), Bangladesh Rural Development Board (BRDB) and the Cooperative Department jointly has been replicating this model (Islam, 2007).

4.3.3. The objectives of TVDP and CVDP

The TVDP was introduced with a view to developing a package programme for an integrated and total development of the villages by bringing all classes of people within one institutional frame-work (Khan et al.,1999). The broad objectives of TVDP were to improve the socioeconomic conditions of all sections of people in the village.

At the initial phase, the following were the main specific objectives of CVDP:

To develop broad-based village cooperative institution involving people of all classes and professions with a view to actively engaging them in socioeconomic activities for poverty alleviation and multidimensional development and welfare of the rural community;

To develop leadership through expansion of the scope of villagers' participation in planning, implementation and decision making;

To mobilize villagers' own capital through savings programme for production, investment and creation of their collective resources;

To use the village institution as the receiving point for all kinds of services and supplies from the line agencies;

To create employment opportunities by undertaking need based investment projects;

To improve production and home management skill, education and social status of women through appropriate education and training;

To undertake community-based primary health care, nutrition and population education activities for improvement of human resources and reduction of population growth rate; and

To introduce continuous education, motivation and training to eradicate illiteracy, ignorance and social stagnation and frustration (BARD Newsletter, 2004)

At the later stage (2nd phase), some modifications were made in the above-mentioned objectives based on lessons learnt from the implementation of the project. As per PP-CVDP (2000) (2nd phase) the specific objectives of CVDP were as below:

To build an institutional setup of voluntary cooperative village development society (CVDCS) for all round development of the village;

To make efforts for developing a cadre of workers from among the members of the village-based organization;

To enable villagers to give leadership and to participate in development activities and also to develop their managerial capability;

To make the village a center of all works by best utilization of local resources; and

To prepare and implement annual plan of development by the villagers with their active participation on the basis of the village information book [PP-CVDP, 2000 (2nd phase)].

4.3.4. Major components of CVDP

The following are the major components of current CVDP:

Organizational Management; Local Level Planning; Savings and capital accumulation; Accounts Keeping and Business Management; Loan Programme; Agricultural Development; Increase Uses of Appropriate Technology; Livestock Development; Fisheries Development; Non-farm Income Generating Activities (IGA); Educational Development; Women and Child Development;

Development of Community Health and Nutrition; Family Planning; Youth Development; Environmental Development and Social Forestry; Rural Communication and Culture; and Monitoring and Evaluation (Project Proforma, CVDP, 2000).

4.3.5. Major strategies of CVDP

The following are the major strategies followed by CVDP to achieve its goal and objectives; Organizing the villagers; Developing leadership; Expansion and intensification of farm and non-farm activities; Preparation of a “Comprehensive Village Resource Book” (CVRB); Preparation of Annual Comprehensive Village Development Plan; Utilization of Village Institution; Developing Rural Industries; Undertaking Health, Nutrition and Family Planning Activities; and Introducing Education, Motivation and Training Programmes (Karim et al., 2003), (BARD Newsletter (2005).

4.3.6. Major activities of CVDCS

The following functions are usually performed by each Comprehensive Village Development Cooperative Society (CVDCS): Weekly Meeting; Collection of Savings and Share; Investment of Capital; Management of the Cooperatives; Village Development Workers; Annual Plan; Credit; Co-operative Training Education; Skill Development; and Marketing (Ahmed, T., 1994), (Khan et al., 1999).

BARD has been implementing 3rd phase of the Comprehensive Village Development Program (CVDP) along with three other organizations. In the 2nd phase, BARD was involved in implementing the project in sixteen *Upazilas* of 15 districts of 5 Divisions. Under this project, one organization in one village is formed to cater to all socio-economic needs of its members. Irrespective of age, sex and socio-economic condition, village people can be a member of a CVDP society. A total of 1020 comprehensive village development cooperative societies with the participation of 1.58 lakh members were formed till December 2015. The 3rd phase (four years long) of the project is being implemented by BARD since October 2018 (Quader et al., 2022).

4.3.7. Objectives of CVDP 3rd phase

The main objective of the CVDP 3rd phase is to organize the village people irrespective of male-female, poor-non poor, occupations, and classes in respect of total socio-economic development and poverty reduction. The specific objectives are to:

Organize a village-based Comprehensive Village Development Cooperative Society for the total development of each village;

Create self-employment opportunities and enhance income in a planned way according to the ability and potentiality of the youths, adolescents, women and men of all families in each village; and

Improve the standard of living and reduce poverty of the villagers through comprehensive development (Quader et al., 2022).

4.3.8. Lessons learnt from CVDP 3rd phase

Although breakdown the continuity of the project substantial numbers of Comprehensive Village Development Cooperative Society or *Samity* successfully sustained without assistance from the project. It is success of the theme of the project.

The Comprehensive Village Development Cooperative Societies at Cumilla and other *Upazila* demonstrates a unique example of sustaining the societies through strong leadership, participatory planning and network with service providers.

CVDCS at the village level acts as a workable platform for the delivery of services of different Nation Building Departments and NGOs.

COVID-19 pandemic hampers the project when training and monthly joint meetings are not organised on schedule.

The successful comprehensive cooperative societies with strong leadership and cohesive approachable to give some financial support to the cooperative members in their financial crisis during the COVID-19 pandemic.

Through CVDP programme, optimum use of local resources, own capital investment and assistance from different government and non-government organizations have made the ‘village cooperative’ a ‘focal point of village development’ (Rahim, Junaed, 2019).

4.3.9. Concluding remarks

The target group and problem or purpose-based approaches had been under extensive implementation for the last few decades. No institution, government or NGOs, could claim that the objectives were fully achieved. In fact, for any rural development programme for reducing social inequality, the rural community should be viewed in its total perspective. The concept of Comprehensive Village Development brought this issue in consideration. The think tankers or promoters of the concept of Comprehensive Approach strongly feel that defiance to reality is the main reason of poor performance of sectoral or target group approach. The theory of integration with people’s participation and bottom-up planning and implementation is being tried to exercise in Comprehensive Village Development Programme. CVDP is addressing the SDG1 (No poverty), SDG2 (Zero hunger), SDG8 (Decent work and economic growth), part of SDG11 (Sustainable cities and communities) and part of SDG16 (Peace, justice and strong institution).

4.4. On-going Action Research Projects of BARD

4.4.1. Statement of the Problems

BARD is always aware of the present problems of poverty, social inequality, agriculture, rural development and is willing to undertake action research to cope with defined problems. The present government vows their mandate “My Village My Town” to realize the declaration of Article 16 of the Bangladesh Constitution, transform the rural economy and bring all the urban facilities to every village. The rural people have their creativity but they need some supports from the local government and village level institutions. Therefore, it is needed to strengthen the capacity of local government and village organizations to provide support services from the government and other sources according to the need of rural people

The government has given importance to rural development in the 7th Five Year Plan and formulated seven strategies such as: 1) income generation in the rural areas and poverty alleviation; 2) rural poverty reduction and strengthening rural economy; 3) developing value chain management in agriculture through cooperative; 4) institutional development and developing the capacity of the rural institutions; 5) strengthening rural cooperative movement; 6) developing service delivery system through the promotion of ICT; and 7) developing rural communication and rural goods transportation.

Based on the above circumstances, at present BARD has been implementing more or less 15 Action Research projects those are directly or indirectly related to poverty alleviation, reducing social inequality, institution building and ensuring social justice. The ongoing Action Research Projects can be classified into three categories as: (1) Livelihood Improvement and Social Development category;

(2) Agricultural Development category; and (3) Women Development and Employment Generation category (Quader et al., 2022).

4.4.2. List of On-going Action Research Projects of BARD by Categories

4.4.2.1. Livelihood Improvement and Social Development category

The on-going Action Research projects of BARD under this category are as below:

Improving Livelihood of Rural People of Lalmai-Mainamati Hill Areas of Cumilla through Integrated Agricultural Farming (BARD part of *Amar Bari Amar Khamar* Project);

Rural Livelihood Improvement through Village Based Organizations and *Union Parishad*;

Floodplain Aquaculture and Safe Food Production through Community Enterprise;

E-Parishad: Khana Profile Database for Improving Socio-economic Condition and Service Delivery in Rural Areas;

Livelihood Improvement of Char Lands' People through Climate Change Adaptation Practices;

4.4.2.2. Agricultural Development category

The on-going Action Research projects of BARD under this category are as below:

Agricultural Mechanization and Collective Farming through Community Enterprise;

Production of Tricho Compost Research and Develop Business Method at BARD Campus;

Development of Rural Poultry Sector and Participation of Women in Income Generating Activities through Kallayan Incubator;

Mushroom Development and Cultivation Centre;

Management and Extension of Dairy, Poultry and Goat Demonstration Farm;

BARD Germplasm Center (Plant Museum);

BARD Demonstration Fish Farm; and

Demonstration of Year-Round Organic Vegetable Production Projects in BARD Campus.

4.4.2.3. Women Development and Employment Generation category

The on-going Action Research projects of BARD under this category are as below:

Women's Education, Income & Nutrition Improvement Project (WEINIP);

Creating Employment Opportunities and Entrepreneurship for Orphan and Vulnerable Qawmi Madrasa Students at Home and Abroad through Vocational and Skills Development Training (Quader et al., 2022).

4.4.3. Core Objective of Action Research Projects

The core objective of all the on-going action research projects of BARD is poverty alleviation and reducing social inequality in Bangladesh.

4.4.4. The Lessons Learnt from the On-going Action Research Projects of BARD

4.4.4.1. Livelihood Improvement and Social Development category

The villagers felt motivated to form village based organizations. The beneficiaries have become interested to make savings. The beneficiaries of the project have gained skills to produce vermicompost,

mushroom production from mushroom spawns. Ducklings and chicken has promoted self-sufficiency of the beneficiaries through producing meat and eggs. Fish fingerlings encouraged the beneficiaries towards adoption of scientific aquaculture techniques in the project area (Quader et al., 2022).

4.4.4.2. Agricultural Development category

Mechanized cultivation through the Community Enterprise has increased production as well as reduced the cost of production. Conclusion about the solid learning from this action research project could be drawn after completion of several agriculture seasons and experimenting with all the ideas.

A community-based approach was found to be effective in the case of safe food production. The floodplain aquaculture communities agreed to stop indiscriminate use of harmful chemicals in their crop field. The PPP (Public, Private Partnership) model of community development showed good performance in the Laksham area in terms of community mobilization, enterprise formation and aquaculture production.

The conventional method of composting from cow dung requires a huge time about 5-6 months and the quantity is also poor. On the other hand, there is a chance of heavy metals (Cu, Zn, Hg, Pb, Ni and Cd) loading in the process of composting by any means. Trichoderma-based composting may be a viable option to overcome the problems. In addition to compost produced from Trichoderma, it will play a very important role in roof gardening and help in producing non-toxic food production.

Village women are very much interested and they gladly accepted the low-cost incubator for hatching the eggs. The overall performance of this incubator is satisfactory; hatchability in terms of chicken egg is 80%, duck 75%, quail 60% and turkey 50%. Many poultry entrepreneurs bought this incubator and they reviewed positively about it.

Routine vaccination against infectious diseases like foot and Mouth Disease (FMD) in cattle is mandatorily is a must in the dairy farm to keep the farm nice to run. Biosecurity practices should be maintained strictly to reduce germ load.

Union household profile is significant both for UP and the common villagers. UP can provide services smoothly using this household profile. Government offices at district, *Upazila* and others can easily establish linkage with this household profile.

A mushroom development and cultivation center has been set up at BARD Campus to test the feasibility of mushroom cultivation where mushroom and mushroom spawn are being produced very successfully.

The adoption and adaptation of climate-smart agriculture options (for example different crops or varieties, cropping systems and management practices) can significantly reduce the negative effects and build resilience to changing environmental conditions..

Availability of natural food in the culture ponds reduces the supplementary feed cost and also increases the growth of species cultured. Bio-floc fish culture in Bangladesh is not well researched and there are some scarcities of essential products in the market. Though it has great potential, still a long way to go with research and development to standardize the process for the farmers. Aquaponics could be the best example of integrated fish-plant culture in a closed environment and if planned properly it will be profitable (Quader et al., 2022).

4.4.4.3. Women Development and Employment Generation category

Using own Capital as Credit with reasonable duration and flexibility increased the economic empowerment of rural women. Imparting trade-based skill training to the females along with credit and technical support increased the option of choice in the production side and their bargaining power.

Women's intellectual strength and networking capacity have been increased by providing technical education and ICT training. Advanced Legal Education with support and advocacy campaign in presence of advocates has a positive effect to reduce violence against women and children. Reproductive Health care and Safe motherhood are enhanced by TBAs and health, nutrition and environmental education which are promoted by study visits and horizontal learning.

An academic approach is more appropriate than an administrative approach in dealing with a conservative group like *Qawmi* madrasas. BARD's approach in bringing them to a government training institute has been successful. *Qawmi* madrasas have a huge demand for skills development training.

The above ongoing experimental projects of BARD are addressing directly or indirectly the SDG1 (No poverty), SDG2 (Zero hunger), SDG3 (Good health and well-being), SDG4 (Quality education), SDG5 (Gender equality), SDG8 (Decent work and economic growth), SDG9 (Industry, innovation infrastructure), SDG10 (Reduced inequality), SDG11 (Sustainable cities and communities) and SDG12 (Sustainable consumption) (Quader et al., 2022).

5. Conclusion and policy recommendations

In this research paper, rural development models and approaches developed by BARD from 60s to till today have been deliberated chronologically and at the same time current action research activities of BARD also have been highlighted briefly. The institutions such as LGED, TTDC, TIP and Two-tier Co-operatives developed from Comilla Approach to Rural Development have also been highlighted judgmentally in this research paper. It has been discussed thoroughly the genesis and transformation process of SFDF from SFDP. All the on-going action research or projects of BARD also been reflected in this research paper. Lessons learnt from the rural development models, approaches and on-going experimentations have been highlighted. The outcomes of the rural development models, approaches and findings of different on-going action research and experimentations addressed some of the most vital SDGs.

5.1. Policy recommendations

The following are some important policy issues that could be considered by the concerned authority:

For developing any effective rural development model some crucial elements like people's participation in the development process, decentralized decision-making, institution building and development of people's organization, development of human resources etc. should be brought under prime consideration. In other words, the theory of integration with people's participation and bottom-up planning and implementation should be considered in developing any rural development model.

The policy planners, government and the research organizations should put due emphasis on rural development experimentations regarding the problem of the tomorrow's poor people along with the current poor people.

Emphasis should be given by the authority for developing rural development model that can create an organizational structure and institutional culture which will ensure the sustainable rural development.

In developing any rural development model, provision should be kept for creating strong human capital base which can be used effectively for poverty alleviation that will also contribute a lot for sustainable rural development.

Leadership component should be included in rural development related experimentations as well as development of any model.

Provision should be kept in developing rural development model for building strong need-based organizations at the village.

Emphasis should be given on such rural development experimentation and developing model which could be created huge employment opportunities at the village level by utilizing the resources available at the villages.

For ensuring sustainable rural development, relevant experimentations should be undertaken so that the rural people could adopt the appropriate modern production technologies as quickly as possible.

Necessary experimentations should be undertaken at the village level for improving home management skill of the women. Necessary educational and training programme could be included in the experimentations for the rural women so that they can contribute a lot with the male counterpart for ensuring sustainable rural development.

For achieving the goals of SDG in Bangladesh above mentioned policy recommendations can play the pivotal role.

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