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Local agricultural practices to adapt with climate change. Is sustainability a priority?

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ABSTRACT

In this paper, we take a sustainability approach to examine whether local adaptation practices to climate change are usually sustainable from an environmental and social point of view. Our hypothesis is that institutional trust is a key enabler of the transition towards sustainable development. To test these concepts, we analyse the local adaptive practices to climate change of agricultural farmers in the drought-prone Northwest areas of Bangladesh through the lens of the UN's sustainable development goals. In our study, we detect that some of the local practices to cope with climate change are environmentally unsustainable. The fact being that securing livelihood is the prime concern for the smallholder farmers. Consequently, local adaptive knowledge often has other objectives than incorporating the implicitly long-run considerations necessary to be on a sustainable pathway, which often clashes with the immediate need to secure short-run livelihood. In addition to this, the lesson we draw from our study is that there is a complex interaction between institutional trust and transition to sustainable development, and a lack of trust in public and private organizations can jeopardize the initiatives of sustainable agricultural development. We conclude that trust in public and private institutions is the key ingredient to reshape the farmers' local adaptation strategies for the sake of sustainable development.

1. Introduction

Agricultural sector plays a vital role for food security and the socio-economic development of various nations. Evidently, this sector is also particularly vulnerable to climate change (IPCC, 2014). The agricultural sector is, by its very nature, exposed to weather events and climate, and climate change has already created and will continue to create challenges for productivity in the all areas of this sector. Water scarcity, drought, erratic rainfalls, groundwater depletion, intensified attack of pesticides are expected to be major challenges for all agricultural sectors in the future (Alam, 2015; IPCC, 2014; Yin et al., 2016).

In the short run, adaptation is the only viable option to create local protection against climate change-related challenges on crop yields. As a result, local farmers are increasingly forced to use adaptation strategies to counter the adverse effects of climatic changes, and many farming communities are trying to adapt to these unwanted changes. (See e.g., Hasan and Kumar, 2020 and Lamiur et al., 2020 for case studies related to Bangladeshi agriculture).

The adaptation processes can be initiated at both national, sub-national and local levels. Undoubtedly, local-level adaption practices are vital for a sustainable development since local communities hold valuable knowledge on the local effects of climate change and experiences about the effectiveness of local coping strategies to counter those unwanted changes (IPCC, 2014; Tripathi and Mishra, 2017). While local adaptation strategies are important factors to mitigate the changing climatic effects on crop yields, there has recently been a gradual global shift towards viewing production and consumption through the lens of sustainability. This also includes scrutinizing agricultural practices for their level of sustainability, including the proposed and already applied adaptation practices. Evaluating agricultural practices in a sustainability context implies making judgments regarding both social, economic, and environmental performance of the agricultural sector.

Several authors challenge the notion that adaptation practices necessarily are sustainable. In a broader political economy framework,

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systemic causes are identified for important sustainability components being absent in local adaptation practices. According to Sovacool and Ola-Linner (2016), adaptation has been corrupted by rent seeking behavior of entrenched interests that are neither appropriate nor effective. Pelling (2011) also put forward the argument that adaptation is a social and political act and embedded into a power relation in society. The author warns that individual adaptive pathways come to dominate or to be marginalized according to power structure and not according to objectives such as equitable and efficient outcomes. In the same line, according to Taylor (2014), it is essential to understand adaptation in a broader context, where choices of adaptation pathways need to address, and preferable include, the underlying systemic socio-political landscape. Taylor (2014) even argue that major barriers to thinking critical about climate change, adaptation and social transformation are created by traditional technocritical thinking about adaptation that unfolds within exiting institutional parameters. This view is supported by Eriksen et al. (2011), who argue that adaptation (by its very nature) not necessarily deals with the social (justice) dimension of sustainability in that it not specially being designed to focus attention on the most vulnerable individuals.

A final complicating factor for adaptation to be inclusive to local needs and knowledge is the issue of consensus-building and local participation in the decision process or in a wider process to reshape the decision frame. Brandt and Svendsen (2013) identify situations where local participation is not optimal for sustainable action. They argue that the process is time-consuming and might hinder real progress. (See also Kurrild-Klitgaard and Brandt, 2021, for a more general analysis of strength and weaknesses of a deliberative decision process).

Hence, lack of sustainability consideration in adapted local adaptation policies can be caused both by the lacking ability of the local community to consider sustainability, since sustainability is an explicitly long-run consideration, and clashes with the need to securing short term livelihood and by the lack of governmental institutions to delegate decision power to the local communities, and the complications that delegative decision processes entail.

We will, however, focus the specific relationship between local farmers and governmental institutions. A proxy for this relationship is farmers' trust into governmental institutions. We argue that the link between local short-term practices and longer run sustainable development is an exchange of knowledge between farmer and governmental officials. We take the trust of farmer in agriculture field officers as a proxy for institutional trust (since the farmers direct interactions to governmental institution is mainly confined to these officers). Trust is measured by the expectation of the farmers that the officers will provide proper assistance and help if needed. Thus, the trust measure provides an indicator for the inclusion of the local farmers into the decision-process, which again, as noted in the literature, is an important precondition for more sustainable adaptation practices.

Based on this, the current paper aims to answer the following questions: i) Are local agricultural climate adaptation practices sustainable? ii) whether inclusion of farmers' local adaptation knowledge and practices into the national policy can contribute in constructing sustainable and resilient agriculture? and iii) whether trust on the public and private institutions can act as a barrier to the sustainable development process? This research applied qualitative methodology, where focus group discussions and semi-structured personal interviewing techniques were used to collect data. The paper is organized as follows. In the next section, we provide an overview of our motivation to conduct this research, while Section 3 discusses our method and hypothesis, followed by a description of the data collection process. The main results are presented in the next section, followed by a discussion and interpretation of the results. Finally, in the last section, we conclude the paper with our perspective.

2. Research motivation

For the farming community, local adaptation practices are playing a pivotal role to adapt to climate change. Farmers' knowledge is a sub-set of local knowledge that enables them to farm in specific local conditions. This knowledge is based on their practical experiences and often linked to practical skills as stated by Sumane et al. (2018). Local experiences to climate change adaptation have merits, and these merits need special consideration into policy making process (Adhikari and Taylor, 2012; Anik and Khan, 2012). Local level adaptation processes have distinguished advances (over governmental top-down policy initiatives) since they are locally rooted. Several researchers claimed that local knowledge must be part of the national policy-making process on climate adaptation (Ayers, 2011; Boillat and Berkes, 2013; Chisanga et al., 2017; Makondo and Thomas, 2018; Sumane et al., 2018).

Local adaptation knowledge to climate change, however, also involve weaknesses, which could act as barriers to sustainable development. Global warming and climate risk are not always accurately perceived by the local farmers, and their adaptations strategies are not always matched with their risk perception as reported by Ahsan and Brandt (2015) and Ahsan (2015). Also, Eriksen et al. (2011) state that little attention has been paid to the consequences of adaptation policies and practices for sustainability and conclude that not every local adaptation to climate change is a good one, from a sustainability point of view. Consequently, the nexus of local practices with climate adaption and sustainable development is complex and it is important to know whether the local knowledge on climate adaptation will lead the society towards sustainable development or whether such adaptation strategies will be forced to rely more on “non-sustainable” practices. This is an important question to investigate, as local practices might not originate from the perspective of an intergenerational sustainability frame, but from an immediate alleviation of the short-run risk management strategy in the agricultural sector. Some local adaptation practices might carry the risk of being unsustainable in the sense that they might trigger even more severe future risks.

The concept of “Sustainable Development” has received huge attention globally. In the literature, many definitions of sustainable development are available. Traditionally, sustainability has been depicted by three-pillars, representing social, economic and environmental performance (Purvis et al., 2019). This study uses this traditional definition of sustainable development to also define a sustainable adaptation policy/practices as being economically efficient without having any significant negative long-term social and environmental consequences.

Nowadays, the UN's definition of sustainable development has become worldwide acceptance which is based on the 17 goals (UN, 2020). In Fig. 1, we have included the 17 SDGs into this “traditional” model of sustainable development. As a case of this research, the farming sector of drought-prone Northwest Bangladesh is closely observed from UN's SDG perspective. The grey box in Fig. 1 represents the direct and indirect effects that the adaptation policies adapted by local farmers in Bangladesh in a sustainability context. Later on, in the discussion section, we will explain how the local adaptation practices are acting as barriers to achieving sustainable development with the lenses of SDG, 6,8,11,12,13,14 and 16. Note the lack of the social dimension in the adaptation practices.

Does the community need strong supports from governmental and non-governmental organizations for sustainable development? Several papers (Adhikari and Taylor, 2012; McNamara and Buggy, 2017; Piggott-McKellar et al., 2019) argue that support from governmental and non-governmental organizations is a prerequisite for sustainable development. McNamara and Buggy (2017) and Piggott-McKellar et al. (2019) provide a detailed literature review on community-based climate change adaptation (CBA). They conclude that focusing on innovation and learning and multi-sectoral approaches are essential. The latter implies that one of the key components of a multi-scalar approach is

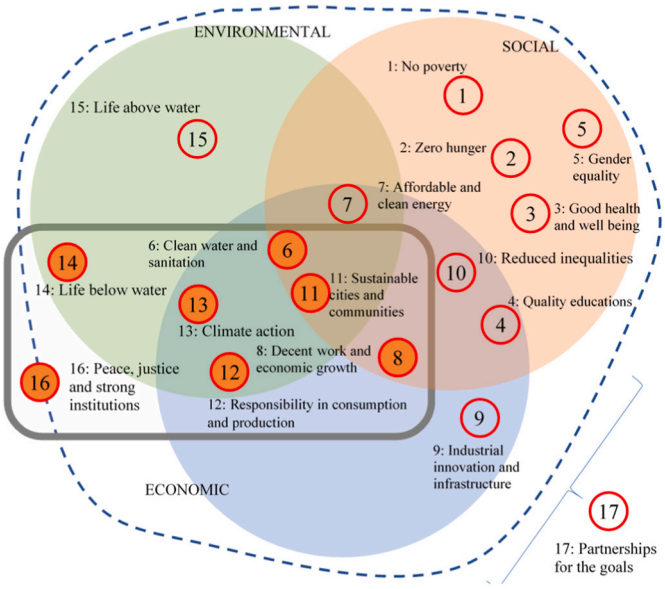

Fig. 1. Adaptation policies influences both on economic, social and environmental issue.

ensuring effective knowledge flows, especially feedback channels linking local-level knowledge and priorities back to national-level policies. McNamara and Buggy (2017) not only stress the important role of institutions, like local and national governments but also the support of non-governmental organizations, donors, are fundamental to shaping adaptation processes.

Finally, why should we be interested in trust? Why does trust in the government matter? We believe enhanced trust on organizations, especially on public authorities, is a driving factor of sustainable development. According to OECD (2013), trust in government "has been identified as one of the most important foundations upon which the legitimacy and sustainability of political systems are built." (Quote page 21). According to OECD (2013), trust, in a broad sense, implies having a positive perception of the actions of an individual or an organization. Interestingly, studies from many developing countries show that poor people report a relatively high level of trust in their government (Hossain, 2008). In Bangladesh, in response to the question about trust in their national government, 86.5% of respondents answered that they had either a great deal or quite a lot of trust on the government (in comparison, in the US only 37.3% had trust upon the government) (WVS, 2016)

For resource-poor people, trust in the government is determined by its ability to address the most pressing issues facing the poorer section of the society, as for example poverty-reduction policies like gratis food supply program, food for work program, etc. Trust is not based on the government's level of inclusiveness, corruption, or efficiency (Hossain, 2008). Still, this high level of trust is puzzling, as corruption is considered a deterrent of trust in the government, and Bangladesh ranked 146 (out of 180 countries) on the corruption index according to the transparencies index.[1]

An integral part of institutional trust is the perceived trustworthiness of institutions. The level of trustworthiness refers to the mechanisms for selecting and regulating the behavior of institutional agents, so that they act in accordance with certain role responsibilities. Askvik and Jamil (2013) stated: "expert observers claim that public office holders are not very committed to institutional policies, their benevolence toward citizens is wanting, their honesty is restricted, their competency is incomplete, and their fairness is partial".

[1] http://www.transparency.org/cpi2019

3. Method and methodology

3.1. Selection of the case

Rice farming in drought-prone Northern districts of Bangladesh is an excellent case to conduct this investigating research as Bangladesh is one of the most vulnerable countries to climate change. Drought-risk hotspots in Bangladesh are mainly located in the Northwestern regions like Rajshahi, Kurigram, Nilphamary, Rangpur, and Dinajpur districts. Causes of drought in Bangladesh are related to climate variability and non-availability of surface water resources. In the Barind tracts (Northwest Bangladesh), both aman rice grown during monsoon and boro rice during the winter season are prone to drought. Shortage of rainfall is one of the major causes of drought in the Barind region (Ramamasy and Bass, 2007). Loss of yield has been becoming quite common in the Barind region.

Our research strategy is to extract local farmers' understandings of climate change, how farming communities cope with climatic changes, what their main challenges are, and what expectations these communities have for support from governmental organizations. To do this, we conduct two separate investigations. First, we examine the local knowledge of rice farmers on climate change, which adaption strategies they are practicing and are these adaption practices environmentally sustainable? In this way, we can point to what resources and general support is most necessary.

Second, we want to identify the impact of trust on public organizations to achieve the goal of sustainable agricultural practices and how farmers' trust on agricultural field officials could be enhanced. We extract the respondents' relevant trust on agricultural extension officers' climate change adaptation advices by directly asking the following questions: "Would you like to change your adaptive behavior (or strategies) if government supports are available? Do you have trust in the advice of agricultural extension officers? If not, what could be done to increase your level of trust?

3.2. Data collection process

3.2.1. Study area and meteorological conditions

For the purpose of the present study, we collected data from the villages of three upazilas (sub-units of districts), Durgapur, Paba and Mohanpur, of drought-prone Rajshahi district (a district of north western Bangladesh) (Fig. 2). The extent and severity of drought have increased both due to rising of temperature and very low rainfall as result of climate change. The economy of Rajshahi is predominantly dependent on agricultural activities. Non-farm activities are not very significant in this district (BBS, 2013), as the growth of the industry is still slow. Out of the total household of the district, almost 56% are based on farming, especially rice farming (mainly Boro). Rice is the dominant food crop of Bangladesh and is also the staple food of the country's people. Boro rice farming in Rajshahi is entirely dependent on irrigated water during the dry season, from October to March. According to BBS (2013), due to low rainfall, some crops of the Rajshahi district are extinct or nearly going to be extinct, including linseed, sesame, indigo and aus paddy (cultivated in the months of March–April and harvested in July–August). Significant losses of agricultural products, increases in input prices, increases in job insecurity and an increased rate of migration (especially among marginal farmers and landless laborers) have been observed as results of severe drought in this area (Islam et al., 2014; Paul, 1998).

3.2.2. Primary data collection procedure

Primary data were collected through semi-structured personal interviews and focus group discussions for this study. The questionnaire includes (but is not limited to) the following questions: how do the local agricultural communities (e.g., paddy farmers) experience of effects of climatic change on their farming? What are their adaptation practices to

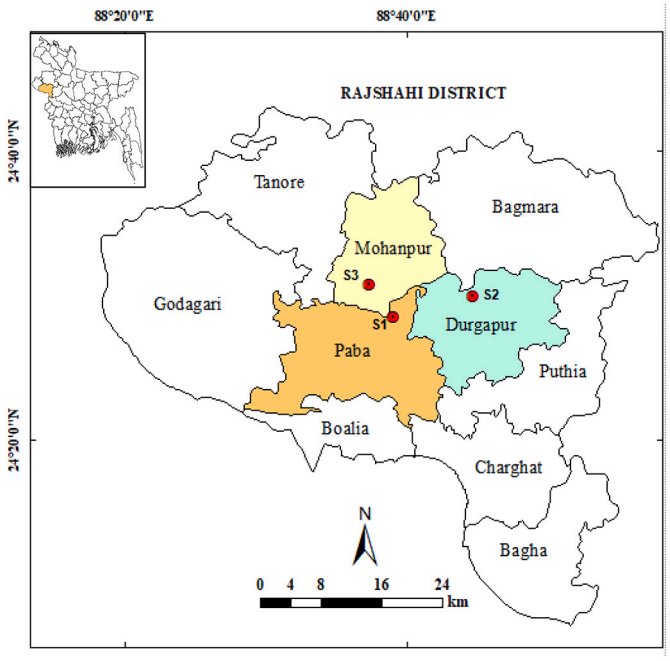

Fig. 2. Map of the Study Area (Survey point S1 = Baragachi, S2 = Palsa, S3 = Mougachi).

cope with accelerating climate changes? What adaptation strategies do they perceive as most relevant to sustainable adaptation? What are the main constraints on adapting to climate change? And finally, what could the government do to support improving the effectiveness of the adaptation process and implemented policies?

A total of 90 households were selected from three villages of three upazilas of the Rajshahi district in Bangladesh. Those villages were Baragachi (Study site 1) of Paba upazila, Palsa (Study site 2) of Durgapur upazila and Mougachi (Study site 3) of Mohanpur upazila (Fig. 2). Households were selected from those whose primary occupation is rice cultivation. The head of each household was asked for an interview. All respondents were male as most of the heads of household in this region are men. Besides those interviews, one focus group discussion at each study sites was organized with 15 participants.

We followed a multi-stage random sampling technique to select the households; this technique has been used in several studies (Boillat and Berkes, 2013; Bouchard et al., 2007; Raymond and Brown, 2011). At the first stage, random sampling was used to select three upazilas. At the second stage, one village was selected from each of the selected upazilas. Finally, thirty households were randomly selected from each village for interviews. The face-to-face interviews were conducted from September 2019 to December 2019. Each interview took about an hour, and all interviews were recorded and transcribed for analysis.

4. Results

4.1. Climatic conditions of the study area

For the purpose of this study, we have collected time series data on temperature and rainfall from 1981 to 2018, provided by the Department of Meteorology from the Bangladesh Meteorological Department (BMD). The data from the BMD show changes in temperature and rainfall over the last few decades. The meteorological data indicate that during the last 38 years (1981-2018) there is an increasing trend in annual average temperature and decreasing trend in annual mean rainfall (mm) in Rajshahi district, and the yearly rate of changes in annual average temperature is 0.02 °C, and − 1.37 mm/year for annual mean rainfall in Rajshahi district (Fig. 3). Temperature anomalies (1981–2018) were calculated based on Tripathi and Mishra (2017) and presented in Fig. 4, which reflecting an increasing trend in both maximum (0.042 °C/year) and minimum (0.009 °C/year) temperature of Rajshahi district, but the rising trend in maximum temperature has been more noticeable. In Bangladesh, March to May and December to January are considered as the summer and winter seasons, respectively (Hasan and Islam, 2013). Fig. 5 showing the trends of yearly average summer and winter temperature of the Rajshahi district over the period of 1981–2015, and an increasing trend in yearly mean summer temperature (0.02 °C/year) and a decreasing trend in yearly mean winter (0.008 °C/year) temperature was observed. Consequently, the secondary data from the literature revealed that the groundwater table in the northwest part of Bangladesh decreased substantially over the period of 1981–2014, with the highest magnitude of 4-12 m in Rajshahi district (Dey et al., 2017). These changes in climatic conditions indicate that overall, the climatic conditions for farming have changed notably and

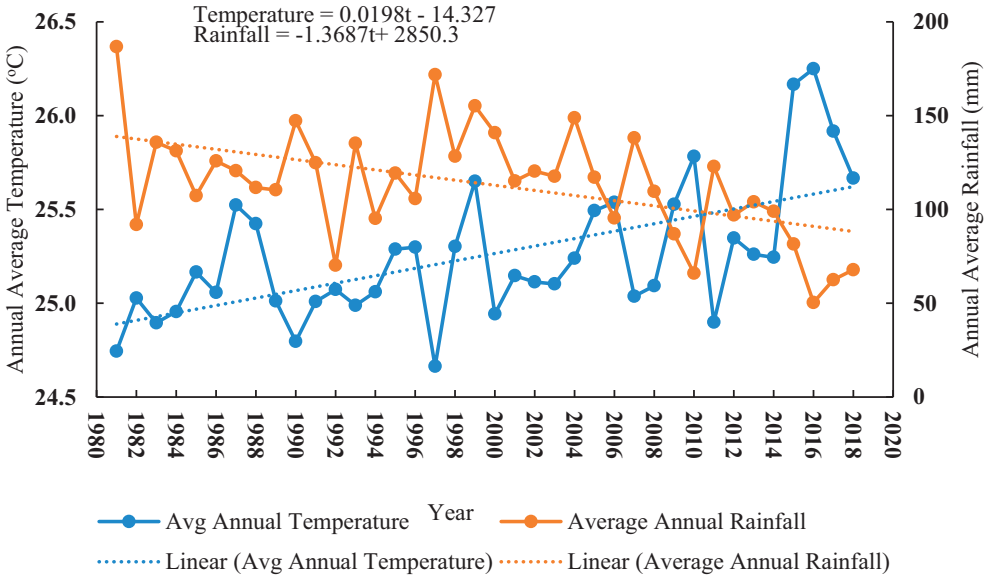

Fig. 3. Trend of yearly average temperature and rainfall (1981–2018) of Rajshahi district. The coefficient of 't' in linear trend equation represent an annual rate of changes for the given dependent variable (e.g., Temperature, Rainfall).

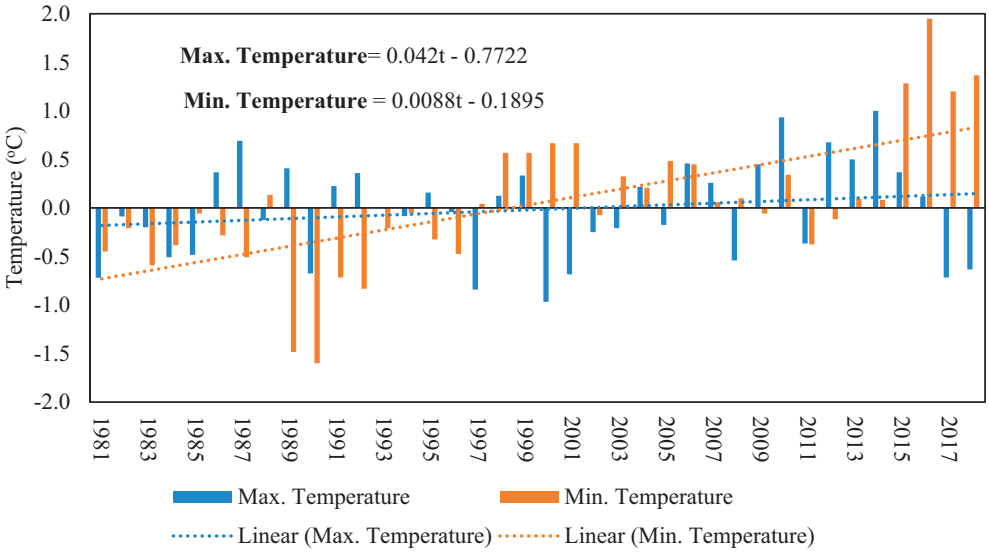

Fig. 4. Yearly recorded average maximum and minimum temperature anomalies is Rajshahi district (1981–2018). The coefficient of 't' in linear trend equation represent an annual rate of changes for the given dependent variable (e.g., Maximum Temperature, Minimum Temperature).

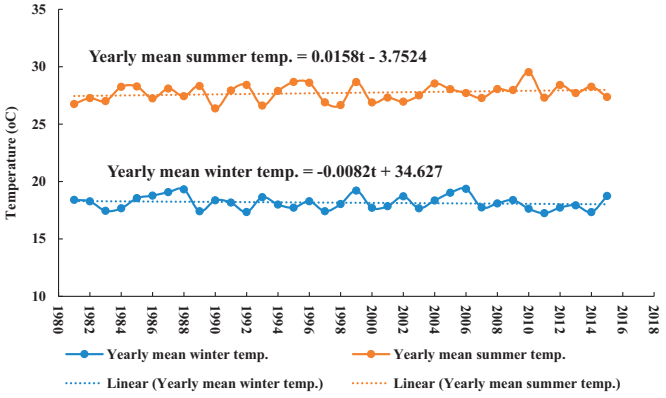

Fig. 5. Trend of yearly mean summer and winter temperature (1981–2015) of Rajshahi district. The coefficient of 't' in linear trend equation represent an annual rate of changes for the given dependent variable (e.g., Summer and winter temperature).

has been creating challenges for farmers.

Increased rainfall variation is the causing more frequent droughts in the north-western region of Bangladesh (FAO, 2007). The anomalies of annual temperature and rainfall are clear. For example, the negative anomaly indicates less rainfall than the mean of annual rainfalls of the observed years. Less rainfall is a real climate-prone risk for the rainfed rice production; severe drought can cause more than 40% damage to "Aus" variety rice (grows under rain-fed conditions in summer) in Bangladesh (FAO, 2007). Post-monsoon drought is also known as Kharif drought as it affects Kharif crops (e.g., Aman rice) (Hossain et al., 2016). Farmers have been coping to this abrupt climatic situation by irrigating their paddy field more frequently using ground water. Securing the livelihoods by avoiding sub-optimal level of yields caused by drought is weighted more than potential longer-run environmental degradation.

4.2. Farmers' experiences of the effects of climate change on their farming

Various socio-economic data of the respondents and a summary of the interviewees' responses are presented in Table 1. Most of the farmers have small or medium-sized rice fields. Most of them are full-time farmers, whereas a few are also involved with other part-time professions like trading, private job, and seasonal labourers. Irrespective of

Table 1
Key characteristics of selected sampling villages.

Attributes	Village		
	Baragachi	Palsa	Mougachi
Location	Paba, Rajshahi	Durgapur, Rajshahi	Mohanpur, Rajshahi
No. of focus group discussion	1	1	1
No. of personal interviews	30	30	30
Farm size	Small (<1 ha) and medium (< 5 ha)	Small (< 1 ha) and medium (< 5 ha)	Small (< 1 ha) and medium (<5 ha)
Full-time	80–85%	75–80%	75–80%
Average farming experience	40 years	30 years	30 years
Key farming	Rice	Rice	Rice
Farming training	No	No	No
Education	Illiterate or educated up to primary (5 years)	Illiterate or educated up to primary (5 years)	Illiterate or educated up to primary (5 years)

study sites, the average rice farming experience of the respondents is 30–40 years. This implies that the farmers have enough knowledge of rice production, and they have practical experiences on the impacts of climate change on rice production in the study area. It also reveals that the farming community has a very low level of education, and the farmers do not have any professional training on farming. So, low level of education and lack of farm management training act as barriers for farmers' adaptive capacity to climate change. Other findings of this study are presented in the following straplines.

4.3. Farmers' experiences on climate change

The data from BBS (2013) also indicates changes in climate variables are relevant in the study area. How do the local farmers perceive these changes? This information could be relevant to understanding their adaptation behavior and their demands and desires from the government, NGOs or even from international donors.

All the participants of the FGDs and all the interviewed respondents reported that they are experiencing certain climatic changes, especially

temperature rise, less rainfall, increases of evaporation, and depletion of groundwater level. In their replies, all mentioned that they noticed an increase in summer temperatures as well as cooler winters compared to the last two decades. They provided other examples such as significant fluctuations in day and night temperatures, seasonal variation (e.g., longer summers, later winters), and low and erratic rainfalls (Table 2). One such respondent of site 1 stated "“I have never seen such a hot and dry summer in my life. The weather was not so hard even twenty-five years ago. Now summer is much warmer, and winter becomes much cooler. The rainy season also becomes shorter and erratic.” The above perceptions of farmers on climate change are in line with the observed trends in climatic variables (Fig. 3-5).

4.4. Farmers' adaptation practices

Most of the farmers who participated in the FGDs and personal interviews complained about low crop yields due to erratic rainfall, intensified pest attacks, increased evaporation, and severe drought (Table 2). The respondents are consistent in mentioning that due to climate change, there are intensified attacks from pests, which also reduced the yields. They need to spread more pesticides than a decade ago. At the same time, the cost of pesticides has even gone up dramatically. Farmer observations are also supported by scientific evidence, as several studies (Cheke and Tratalos, 2007; Dangles et al., 2008; Staley et al., 2007) have indicated that climate change has substantial effects on the increased growth of insect populations and on crop damage.

Table 2
Farmers' experiences of climate change and local adaption strategies.

Effects	Some key statements of respondents	Adaptation strategies
Decreased rainfall and drought Temperature rise Increased evaporation Erratic rainfall	“*I have never seen such a hot and dry summer in my life. The weather was not so hard even twenty-five years ago. Now summer is much warmer, and winter becomes much cooler. The rainy season also becomes shorter and erratic.*” “*Rice farming is becoming more expensive and challenging due to crop yield variation. We are using more ground water, but the water level is falling, and we need to re-dig our wells, which is costly,*” “*The trends of seasonal variation and fluctuation of temperature gradually implies decreases in yields of rice and other agricultural production*” “*Though ground water is falling down gradually, still we are using more water to survive with the changed climatic condition,* and we have no other options”	• Increased irrigation with ground water • Crop diversification (e.g. horticulture instead of rice culture) • Diversification into non-farm activities • Stop farming activities and find alternative jobs
Intensified pest attack	“*I am experiencing attacks from more pests, some of them are even new in our locality. I am now using higher doses of pesticides to eradicate those pests as prescribed by the local dealer. The dose and cost of the pesticides are also climbing up every year.*” “*We are struggling to secure quality inputs. Therefore, the quality of pesticides and other inputs should be ensured and there must regular monitoring systems by public authorities.*”	• Use of more pesticides to eradicate the pests • Use more chemical fertilizers • Crop diversification (e.g. horticulture instead of rice culture) • Diversification into non-farm activities • Stop farming activities and find alternative jobs

“Decreased rainfall and fluctuation of temperature are largely affecting the farming economy,” as mentioned an elderly (age 60) farmer from study site 2. Groundwater irrigation is the main source of water for rice cultivation, especially in the dry season. To offset the adverse effect of less rainfall and erratic monsoon season, farmers have been using groundwater and the irrigation need is increasing day by day due to less rainfall (Table 2). In addition, there is no limit/control to use of groundwater, and usually the farmers use more water than actual need. Less rainfall and indiscriminate use of groundwater are the major reasons for the dropping of groundwater level (Aziz et al., 2015; Dey et al., 2017). As groundwater table is gradually falling down, farmers need to re-dig wells on a regular basis, which is costly and environmentally unsustainable. We will address this us-sustainable practice in the discussion section.

4.5. Barriers to adapt with climate change

As already indicated, farmers face a series of challenges due to changing climate. Therefore, we asked more specifically about what constraints the farmers perceive as most important concerning adapting to the changing climate. The main challenges are grouped into 5 categories (Table 3) and explained under the following sub-headings;

4.5.1. Dropping of the groundwater table

Farmers are worried about the increased cost of irrigation and the diminishing supply of groundwater irrigation because the water table is drastically falling. The groundwater level has depleted at the rate of 40 cm/year over the last 34 years due to excessive irrigation (Dey et al., 2017). In 1985, when tube-wells (for irrigation) were first introduced in Rajshahi, the water table was 10 m below the surface. However, 20 years later, it had dropped by another 3–12 m below ground in some areas of the Rajshahi district (Amin, 2011). The farmers need to re-dig the tube to adjust to the falling water table. The amount of water required for irrigation has also increased as the drought has worsened due to climate change. In addition to the increased cost of irrigation, it is also threatening the environment as the groundwater level is falling gradually.

4.5.2. Access to new technology and lack of advanced farm management training

As it is mentioned in FGDs and interviews, the farmers are using traditional techniques to cultivate rice, which requires a lot of irrigated groundwater, especially during the growing stage of the plants. High-yield varieties, which are presently cultivated, also need abundant water. Thus, farmers emphasized the importance of innovation and the availability of new technology, which could help them to survive against the effects of climate change (Table 3). They are also eager to be trained and to develop their farming skills. All the interviewees expressed that new cultivation technology (which demands less irrigated water, use of less pesticides and inorganic fertilizers), the introduction of cost-efficient irrigation technologies, and drought-resistant cropping are urgently needed to adapt with changed climatic conditions. “We have no other options as there is not much profit in farming these days, and, we need to cope with the increased production costs; therefore advanced training on farming, reduction of post-harvest loss and overall farm management are desirable to reduce the production cost.” as illustrated by a 40 years old farmer from study site 3.

4.5.3. Low quality inputs (e.g. pesticides, seeds, fertilizers) and increasing price

Spurious and low-quality pesticides, seeds and fertilizers are the big challenges for the rice farmers as mentioned by the majority of the respondents (Table 3). During FGDs farmers stated that they are experiencing attacks from more pests, some of the pests are even new in their locality. To mitigate the damage from pest attacks, most farmers are now using higher doses of pesticides to eradicate those pests as prescribed by the local pesticide dealer. The dose and cost of the pesticides are also

Table 3
Key barriers towards sustainable adaptation strategies and institutional supports needed.

Barriers	Some key statements of respondent farmers	Supports needed to overcome barriers
Falling of groundwater level	"*I am experiencing that the groundwater level is dropping every year as I need to … but what else could I do? I have no alternative job options than farming. Furthermore, I have no training to start another type of farming than rice cultivation.*"	• Human skill development through training • Creation of local resource pool and regular knowledge-sharing platform
Lack of access to new technology and training	*"Maybe many of us are illiterate or semi-illiterate, but that does not mean that we will not be curious about new inventions and not capable of adopting them to improve our practice of cultivation. Lack of proper training and knowledge disseminating policies, make it difficult to adopt new agricultural interventions to fight against the risk of climate change."* "*The field level officers should play a pioneering role in this regard, and the government should compensate if the demonstration trials become unsuccessful. This is important not only to increase the credibility of the new crop or technology but also to uphold trust in the field officials*".	• Locally adjusted innovative technology • Human skill development through training • Stakeholder inclusion in policy formulation and implementation process
Low quality farming inputs (e.g. pesticides, seeds) and price	"*Drought intensity due to climate change is threatening our livelihoods. I need to pay approximately 25–30% of the price of the harvest just for irrigation. However, approximately 20 years ago the cost was approximately 5–7%.*" "*….my ability to control pest attacks is declining because the effectiveness of commonly used pesticides seems to be reduced and I need to use more. This also increases production costs significantly.*"	• Creation of local resource pool and regular knowledge-sharing platform
Access to the formal credit system	"*The government has made some new policies to ensure easy access of the farmers to agricultural credit, yet the policies adopted by the government are not enough to ensure credit facilities for marginal farmers like us.*"	• Easy access to agricultural loan with low interest rate
Lack of trust on public organizations	"*My trust in the agricultural officer has been diminished as I have already experienced loss from a project after cultivating new crops prescribed by the governmental agriculture supervisor, but they did not take any measure to compensate my loss. So how could I trust them?*"	• Inclusive decision-process where the farmers problems and need are at the centre • Alignment of expectation between farmer and extension offers are clear and well understood

climbing up every year. Therefore, farmers find that rice cultivation is becoming more expensive, not only due to increased costs of irrigation but also due to the cost of pesticides. Farmers also reported that many of them have no clear idea which pesticide is to be used for which crop and also lacking proper training to use the proper dose of pesticide to control pest attacks. As mentioned earlier, the pesticide dealers are prescribing to increase the dose of pesticide day-by-day as the effectiveness of pesticides is declining. Farmers are just following their advice. Sometimes, the farmers feel that they have been cheating by the local pesticide dealers as the effectiveness of pesticides is very low, and there is a big question about the quality of pesticides. Therefore, many farmers believe that the traders are selling impure/low-quality pesticides to make more profit, and there is no control over selling or quality checking as the governmental institution has less control and there is no quality check of the pesticides available in the market. Farmers also need to use more chemical fertilizers as soil fertility is diminishing.

4.5.4. Lack of access to credits

FGD participants and almost all interviewees mentioned that credit constraint is considered one of the most vital barriers to adaptation, especially for marginal farmers (Table 3). According to their statements, commercial banks are only interested in medium and large scale farmers. Small or marginal farmers have no access to formal credit facilities. Therefore, these groups lend money from private money lenders and local credit NGOs with high-interest rate than the formal banking system. Credit constraint is a big problem not only for agricultural farmers but also for other farming communities like fish farming in Bangladesh as pointed out by Ahsan (2015).

4.5.5. Lack of trust on public organization

Agricultural extension services to build farmers' capacity is important for adaptation to climate change (Tripathi and Mishra, 2017). A high level of accountability on governmental officials influences public trust by improving citizens' satisfaction. Hence, trust on officials of the agricultural extension department and other public organizations is the key factor in achieving the national goal of sustainable development by mitigating the consequences of climate change.

Our study indicates that most (except for three) respondents in the three sampling sites reported that they do not have easy and friendly access to government extension services which are the key hinders for high level of trust and satisfaction on agricultural officials (Table 3). In all three sampling villages, farmers expressed their dissatisfaction not getting proper assistance from the block supervisors whenever they needed it.

"My trust in the agricultural officer has been diminished as I have already experienced loss from a project after cultivating new crops prescribed by the governmental agriculture supervisor, but they did not take any measure to compensate my loss. So how could I trust them?" as argued by a farmer of survey site 3. During the FGDs and interviews, almost all farmers agreed that rice farmers are reluctant to try with new crop varieties due to fear of production loss and no public incentive is available to compensate for the unexpected loss. A farmer of site 3 said "I saw last year when one of my neighbors tried to adopt a new variety of rice as per the advice of the agricultural block superior, but that trial was unsuccessful, and he did not receive any compensation. Only gratis seed and fertilizers are not enough to support me, who will pay my labor and other costs?" These statements indicate that lack of trust or confidence on the agricultural extension officers is an issue, especially among those farmers who did not experience good results from new crops. Farmers also claimed that there is a lack of friendly farmer-officer relations.

4.6. Demands from the farmers to the government

Overall, our investigation shows a need for more governmental support, both concerning help from/cooperation with agricultural field officers as well as lack of advanced agricultural training and risk-sharing

arrangements with governmental institutions. Some of the key barriers mentioned by the respondents will be elaborated below, while some have already been addressed in the preceding sections.

All the respondents emphasized that farmers should be involved in each step (e.g., project concept development, planning, and project implementation) of any agricultural projects aimed at adaptation to climate change. Such an inclusive policy will create a high level of farmer-officer cooperation and a friendly atmosphere to express the real needs of the farmers to adapt to climate change. The respondents also stated that field officials need to dedicate their best efforts to promote modern technologies and at the same time need to be open to gathering local experience and listening to local needs regarding adapting to climate change. All the respondents believe that regular information-sharing meetings and seminars at the field level with all stakeholders could enhance improved farmer-officer relationships and trust (Table 3). Farmers are not only eager to receive training but concerned about how to organize such training in a productive manner. According to the farmers' opinion, to convince them to new cultivation techniques (or encouraging them to use new varieties) requires a combination of advanced training and involvement of the trainees in testing the disseminated knowledge via demonstration/experimental agricultural plots.

During the FGDs at three study sites, farmers pointed out that demonstration plots are essential tools to visualize the efficacy of any newly invented drought-resistant seeds and advanced cultivation methods, the respondents are not satisfied with the current policy related to the demonstration plots. Under the current policy, there is no means of compensating a farmer's income loss if the demo trial is unsuccessful or unprofitable. So, the farmers urge that there should be a provision of cover the full loss if an experiment with a new variety becomes unsuccessful. This policy is also essential to maintain a high-level trust on governmental agricultural officials. “The field level officers should play a pioneering role in this regard, and the government should compensate if the demonstration trials become unsuccessful. This is important not only to increase the credibility of the new crop or technology but also to uphold trust in the field officials as stated by a senior farmer at site 3. During the interview, a similar opinion is given by a respondent of study site 1 “To ensure our motivation to use the new technology and hold our confidence level, the government should not only bear the cost of fertilizers and seeds for the displayed plot but also take responsibility if production from the displayed plot is not economically profitable. Otherwise, the farmers around the plot will not be motivated to adopt the new technology even though it might have the potential to help them”.

While we were conducting the FGDs, farmers stressed that frequent “farmers-extension officers-input suppliers” meetings are essential to ensure the quality of farming inputs. They also mentioned that providing feedback at the subsequent meetings can help to measure the effectiveness of new agricultural inputs and techniques. During the meetings, the performance of agricultural inputs will be discussed to ensure quality and to control the risk of bad or impure inputs being supplied by the input dealers. So, an “input quality check monitoring cell”, comprising of farmers, input dealers and other relevant stakeholders would be a good step to overcome the problems with low-quality inputs.

Farmers are also concerned about the resources needed to train the huge farming community. They are fully aware that it might not be possible for the government to provide advanced training to all farmers. Therefore, they suggested that advanced training should be provided to at least two or three farmers (especially young farmers) from each village who will then disseminate the knowledge to their neighbors by implementing the new technology at their farms.

5. Discussion

In this section, we are going to synthesize the results of our research presented in the previous section.

The first research question of this study is, “Are local agricultural climate adaptation practices sustainable?” The second questions “is it that always important to include local practices and knowledge in the decision-making process for sustainable development?”. Hence, what types of practices and local knowledge could these be and to what extent are they used, and if not, why not? Our third research question is, “is lack of trust on public and private instructions a barrier of sustainable development?”

Our research points out three main components of potentially non-sustainable local adaptation practices in response to climate change which are i) using more ground irrigation, ii) application of more pesticides, and iii) using more fertilizers. Fig. 6 highlights the problems associated with the local adaptation strategies.

Regarding the use of pesticides, it seems that the farmers do not have enough knowledge of the efficient use of pesticides and the quality of these pesticides. In addition to transmitting better knowledge of when and how much to use, there is also a need for improved control of the type and quality of the pesticides. So, this indicates that local knowledge and adaptation strategies are always not sustainable and organizational supports are needed to train up the local farmers with sustainable adaptive capacities as also mentioned by Xu and Grumbine (2014).

Furthermore, from a sustainability context, the inefficient use of pesticides is dangerous for the environment. According to OECD (2013), a sustainable approach to plant protection requires a holistic approach that includes economic, social, and environmental aspects as well as possible impacts on biodiversity. Hence, integrated pest management will be considered the key strategy for the sustainable use of pesticides. The farmers claim that they are now using higher doses of pesticides to eradicate the pests as prescribed by the local pesticide dealer, and more importantly that they feel that they have been being cheated by the local pesticide dealers for years as the quality and effectiveness is questionable. The government appears to be in urgent need of taking strong punitive measures against the marketing of spurious seeds, fertilizers and pesticides to save the peasants and for sustainable development in the agricultural sector

Spurious pesticides and chemical fertilizers (e.g., Urea, Triple Superphosphate, Diammonium Phosphate, Boran, etc.) are not only posing a negative effect on the farm economy, soil's natural fertility but also on the environment. There are two key unsustainable dimensions in considering pesticides and inorganic fertilizer's role in the environment, in its production and use. Production processes can have effects on both air and water quality. Improper application of pesticides and fertilizers can contaminate groundwater aquifer and stream water. In Bangladesh productivity of freshwater fish is declining significantly and one of the main reasons behind this is pollutants runoff from agriculture.

The rapid increase of food production must not ignore the necessity for guarding environmental quality, which is one of the key component of sustainable development. Therefore, the irrational usages of groundwater for irrigation must be controlled for environmental sustainability. We believe, from a local economic perspective, efficiency could be achieved through better knowledge about when and how much water to use (to reduce costs and increase effectiveness) and by taking into consideration the importance of protecting the groundwater. Current irrigation practice is unsustainable and will create pressure on future water security. Though farmers are aware of the adverse effect of overuse of groundwater, still they are overusing the groundwater, which might only be sustaining their income rather than environmental sustainability. Tripathi and Mishra (2017) also revealed the same finding from the agriculture sector of India.

The results of our study also indicate that the promotion of more crops that require less irrigation has become a crucial task because the groundwater table has been declining abnormally in the region. In response to this, the Bangladesh Rice Research Institute (BRRI) has invented drought-tolerant rice varieties for the drought-prone areas which require minimal irrigation and a short maturity period still giving a high yield. More research is, however, needed to invent more drought-

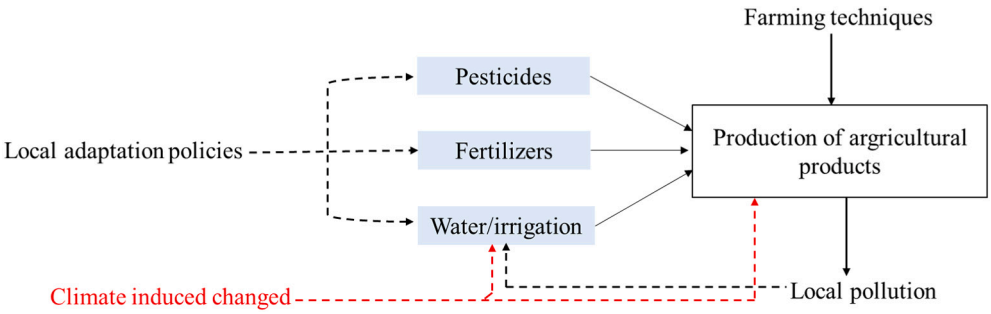

Fig. 6. The main sources of potentially non-sustainable adaptation practices.

tolerant rice and other crop varieties enabling farmers reduce or even eliminate the huge economic losses and, equally important, sustaining national food security. Furthermore, it is necessary to help the farmers develop their skills by familiarizing them to the new farming technologies and knowledges. For example, proper seed preservation training can assist farmers to have their own seed banks saving them from being cheated by the dishonest seed distributors. For these purposes, farmers' organizations at the grassroots level need to be organized to train the farmers with new technical options for transitioning to sustainable agriculture.

Several aspects such as societal, organizational (e.g., support from the public organizations, input suppliers) and personal factors (e.g., own motivations, values) underpin farmers' decisions to move towards sustainable farming practices (Sumane et al., 2018). Furthermore, trust in institutions and trust of public and private agents are very important attributes for the success of sustainable development. For a small farmer, to devote time and resources for being part of a new adaptive technology/practice and to truthfully pass knowledge to governmental officials, this farmer needs to trust that concerned official has real influential power and that the information passed by the farmer is not being misused. Hence, mutual trust is necessary and in particular that government agents and governmental institutions need to address the issue of local acceptance of adaptation policies by including the locals' special needs and based on the local socio-economic context. But also, the governmental agents play their role as facilitators (Adhikari and Taylor, 2012), and particularly as facilitating feedback channels linking local-level knowledge and priorities back to national-level policies (McNamara and Buggy, 2017).

Considering the aspects described above, it is evident from our study that lack of trust on public and private institutions acts as a barrier of sustainable development. It has been already mentioned that farmers' have less trust on the dealers of input suppliers and government agents (agricultural extension officials). When analyzing the responses of FGDs and interviewees, we notice that farmers do not feel that they are included in any decision-making processes. The farming community points several challenges such as lack of assistance from the agriculture officers, lack of resources and knowledge to acquire access to new technology. These issues should be addressed by public authorities. Farmers also suggest that advanced farm management training should be provided to at least two or three farmers from each village, which so far has not been accommodated in the policy level as in developing countries like Bangladesh government usually follows a top-down approach. Thus, the concern of the farming community seldom reaches to the top administration and policymakers. This is a common piece of wisdom reflected by Pender (2008): "Whatever strategy is adopted, however, it should start with and be led by the local community whenever possible for it is the local village people who are often the real experts on climate change". With this lack of or low participation in the decision-making process, farmers have a low level of trust on the governmental agricultural extension officials. But, when there is a need for the development of new skills and innovative farm management practices, peasants' trust and confidence on governmental officials is crucial as small farmers cannot take the risk of harvesting failure from an experiment of a new crop variety. Demonstration trials for introducing new crop varieties (for instance, drought-resistant high yield rice varieties) to the farmer is a very effective tool. But several trials might need to be successful, but many marginal farmers could not even survive if the first trial fails, as there is no policy to compensate the economic loss due to unsuccessful trials (except giving free seeds and fertilizers for a trial). Therefore, many farmers are less willing to take the extension officers' advice regarding new variety. So, to increase the level of trust in the agricultural extension officers, the government should take a pragmatic scheme to compensate for the total economic loss that occurs from any unsuccessful trial.

Another key challenge is how the transmission of local knowledge and need of demands can take place in a situation of low mutual trust among farmer-public officials-input traders. So, for the enhancement of farmers' level of trustworthiness into the government, some efficient policy measures should be taken to transmit information and local knowledge from farmers to the government agencies and vice versa. For example, the most intriguing suggestion is to provide a small number of local farmers in a village with advanced training and/or new technologies and then to have these farmers serve as reference persons for local villages wanting to acquire the necessary relevant knowledge. In this way, more general farming practices can be tailored towards the local knowledge base and specific local circumstances. This solution stands out as the most promising way of generating synergy between local knowledge and more general knowledge provided by governmental officials.[2]

Here, we also stress that local knowledge needs to be combined with more innovative farm management skills, such as proper application of water, fertilizers, and pesticides; modernized farming techniques, etc. Using innovative technologies in agriculture can ensure environmental, social, and economic sustainability, so emphasis must be placed on agricultural research and innovation. Recently, the government has adopted a new policy to promote mechanized agricultural systems by providing subsidies on agricultural machineries like Power tillers, tractors, reapers and combined harvesters which are now importing from Korea, India and China. Farmers need to pay half the price of the farm equipment and the government bears the remaining costs. In some areas (e.g., coastal zone and the north-eastern area) farmers only need to pay 30% of the prices of the machineries while the government pays the remaining 70% from the state offer. There is no VAT on imported agricultural machinery.

As Bangladesh is a sub-tropical country, use of solar water pumps could be a good option for the farmers, as it will reduce the costs compared to that is needed to irrigate the crops using diesel pumps.

[2] This suggestion could also be combined with more far-reaching models of local inclusion, such as the idea of "Developing community-led micro-plans for improving livelihoods and climate change adaptation: http://www.icimod.org/?q=20992

Solar water pumps are also preferable from an environmental point of view, being a fully renewable source of energy. However, the main constraint to motivate farmers to use solar water pumps is the large initial investment. Farmers need to purchase the water pumps and panels all at once. As mentioned in the previous section, the government adopted a supportive policy for agriculture mechanization by providing subsidies, supporting the farmers when buying modern machineries. Preferably, the government could also extend the support to include eco-friendly equipment like solar water pumps for modern irrigation systems. Rainwater harvesting is considered an effective adaptive measure to combat water scarcity during drought period (Mahmoud et al., 2016; Hossain et al., 2016) specially when a pond is located nearby the rice field. This adaptive measure is, however, not suitable for large-scale farming as well as for farmers who have no ponds to reserve rainwater. Since the private sector is also playing a leading role in the agriculture development in Bangladesh, it is also necessary to raise funds for their innovative research on sustainable agriculture.

Apart from giving a boost to farm mechanization, the government should have policy of how to empower the farming community by linking them to the marketing channel. Usually, the farmers cannot get good price at pick harvesting time. Small farmers bound sale their produce at low price to the wholesaler, who then stock rice (and other grain) to their warehouse and sale at elevated price in the lean period. To solve this problem, both governmental and private initiatives must be taken on an urgent basis. Pelling (2011) and Taylor (2014), argued that sustainability also includes changing the underlying structures of the socio-political landscape. To achieve that, empowerment of marginalized group is essential, in particular female farmers and illiterate farmers.

Though gender equality is a precondition for the sustainable development, women's contribution in agricultural sector is still undermined in Bangladesh, and there is a lack of proper policy framework to empower them. In Bangladesh, women exceed 50% of the agricultural labour force (FAO, 2016), also doing work in the fields. However, women's participation in agricultural commodity marketing is very insignificant and usually not connected with the market. From sowing seeds to harvesting, women do almost all kinds of agricultural work. However, women's decision-making power is not yet well established, and the development of women leadership capacities can play a pivotal role for transition to sustainable agriculture. Women's participation in agricultural sector must be recognised. Recently a few models on women's empowerment in the commercialization of subsistence agriculture and decision-making processes have been implementing by NGOs.

Finally, in Table 4, we give an explanation about in what way the chosen SDG's have relevance for our study, based on our findings and the general research question we address in this article. Table 4 indicates that SDG 6, 8, 11, 12, 13, 14 and 16 are directly relevant to our study. However, the focus of our paper is particularly on SDG 13 and SDG 16. In the precision of SDG 13, we find that 3 sub-goal if relevant for our study. In sub-goal 13.1, the focus is on a response to climate change, that strengthens resilience and adaptive capacity to climate-related hazards and natural disasters in all countries. It also requires that the climate change measures be integrated into national policies, strategies and planning (13.2). Finally, sub-goal 13.3 stresses the importance of improving education, awareness-raising and human and institutional capacity on climate change mitigation, adaptation, impact reduction and early warning.

We detect several unsustainable practices in an attempt to adapt to climate-induced changes locally. This includes using more pesticides, fertilizers and groundwater are not sustainable adaptation strategies, as these strategies have substantial negative impacts on the ecosystem. Already there is an alarming decline in groundwater level which would be fall further if irrational use of groundwater is continuing. Besides this imbalanced use of pesticides could lead to severe ground water pollution and damage of freshwater aquatic resources.

Table 4
The SDGs that are relevant in our analysis.

SDGs	Relevance for our study
(6) clean water and sanitation	Adaption based on extracting more groundwater resulting in less availability of drinking water as groundwater. Extensive use of pesticides could also affect groundwater aquifers.
(8) decent work and economic growth	The lack of knowledge and resources to cope with pests and droughts will negatively affect local economic growth
(11) sustainable cities and communities	The underperformance in SDG 6 and SDG 8 implies major barriers to sustainable development in the local farming communities
(12) responsibility in consumption and production	Risk of non-sustainable practices leads to non-sustainable production
(13) climate action	Climate actions need to be integrated into a larger frame of sustainability.
(14) life below water	Extensive use of pesticides and fertilizers leads to run off from farms into rivers, lakes and ponds, which are negatively affecting animal life and fisheries.
(16) peace, justice and strong institutions	Lack of trust into governmental institutions and the perceived non-trustworthiness of these institutions lead to barriers to alleviate the above non-sustainable practices and production consequences.

Note: Each SDG contains several sub-goal and indicators. We include a SDG if at least one sub-goal has relevance for our study.

To improve this problematic situation and bring it in better in alignment with SDG 13.1, the farmers should become familiar with modern methods of protecting the environment. There is a need for a farmer-friendly atmosphere in which to implement sustainable local adaptation policies. The farming community should be involved as much as possible and should be made a part of the process to maintain its high cooperative potential. In order to properly integrate local adaption practices into national policies (as required by SDG 13.2), we feel the government of Bangladesh needs to overhaul its policy decisions and think of pragmatic measures concerning this issue. The governmental institutions should build a close partnership with the local farming community as also stated by Islam and Nursey-Bray (2017). While using the lens of SDG 16, we notice institutional shortcomings, which materialize the lack of trust. The governance system is very crucial to support the local farming community by adopting sustainable adaptation policies to achieve the SDG goal.

Bangladesh has a long history of providing extension services to the farmers, but the effectiveness and efficiency of the national agricultural extension system has remained low (Afrad et al., 2019). Lack of service-minded attitudes and low technological competency of extension officials are considered as the key barriers to develop an efficient and effective extension service. Service quality delivered by the governmental extensional officials is seldom satisfactory though quality services are considered as the foremost dimension of farmers' trust on the extensional officials. Furthermore, according to a study by Quaye et al. (2019), like many other developing countries, in Bangladesh agricultural extension services mainly address male farmers. However, it is evident that women have a key role in agriculture, so extension practices must be gender-sensitive and aimed towards gender equity to increase level of trust and collaboration. It is also important to involve more women officials in agricultural extension services to develop a close and trustworthy relationship with the women farmers.

Specially farmers who have low level of literacy, are failing to receive the optimum benefits from the public extension services. Moreover, there is lack of well-organized farmers' cooperative societies to support farmers and a total lack of an efficient bottom-up strategy to ensure farmers' active participation in extension services (Afrad et al., 2019). Innovation, use of digital technology on agricultural extension service and a great service-oriented attitude of the governmental extension

official could certainly motivate and encourage farmers to get rid of unsustainable practices by adopting innovative solutions. And undoubtedly, this will support Bangladesh's journey to ensure national food security and its transition to a fully sustainable agriculture.

Hereby, we also stress that trust in public and private institutions is the key ingredient to reshape the farmers' local adaptation strategies to be more sustainable wherever necessary. To ensure sustainable development in agricultural sector, it is imperative that the existing gap in agricultural policy; lack of harmonization among farmers, intra government institutions and private organizations are addressed properly.

6. Conclusion

In conclusion, we address that local adaptation measures taken by farmers to combat adverse effect arising from climate change may not always incorporate a sustainable dimension but rather provide short-term solution to secure bread and butter.

We also emphasize that trust in public and private institutions is a key ingredient to successfully introduce innovative measures to tackle the effect of climate change on crop yield. Traditional top-down approach in a public agricultural extension service system can act as a barrier for the creation of the mutual trust, which jeopardizes the initiatives for sustainable agricultural growth.

On the contrary, using an inclusive and supportive decision-making process makes it possible to develop a high level of institutional trust which will not only support food security and livelihoods for the current generation but also do not undermine the prospects of food security and environmental protection for the future generations.

Declaration of Competing Interest

We declare that we have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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References

Adhikari, B., Taylor, K., 2012. Vulnerability and adaptation to climate change: a review of local actions and national policy response. Clim. Dev. 4 (1), 54–65.
Afrad, M.S., Wadud, F., Babu, S.C., 2019. Reforms in agricultural extension service system in Bangladesh. In: Agricultural Extension Reforms in South Asia: Status, Challenges, and Policy Options, Chapter 2. Academic Press, pp. 13–14.
Ahsan, D., 2015. Employees' perception on risk and risk management: evidence from Danish offshore wind industry. Paper prepared for the world congress on risk conference in the context of risk analysis for sustainable innovation, Singapore (19–23 July, 2008).
Ahsan, D., Brandt, U.S., 2015. Climate change and coastal aquaculture farmers' risk perceptions: experiences from Bangladesh and Denmark. J. Environ. Plan. Manag. 58 (9), 1649–1665.
Alam, K., 2015. Farmers' adaptation to water scarcity in drought-prone environments: a case study of Rajshahi District, Bangladesh. Agric. Water Manag. 148, 196–206.
Amin, A.R.M.R., 2011. Bangladeshi farmers look beyond rice as wells run dry. https://news.trust.org/item/20110718115800-s1nfl/. (Accessed 15 February 2021).
Anik, S.I., Khan, M.A.S.A., 2012. Climate change adaptation through local knowledge in the north eastern region of Bangladesh. Mitig. Adapt. Strateg. Glob. Chang. 17 (8), 879–896.
Askvik, S., Jamil, I., 2013. The institutional trust paradox in Bangladesh. Public Org. Rev. 13 (4), 459–476.
Ayers, J., 2011. Resolving the adaptation paradox: exploring the potential for deliberative adaptation policy-making in Bangladesh. Glob. Environ. Polit. 11 (1), 62–88.
Aziz, M.A., Majumder, M.A.K., Kabir, M.S., Hossain, M.I., Rahman, N.M.F., Rahman, F., Hosen, S., 2015. Groundwater depletion with expansion of irrigation in Barind tract: a case study of Rajshahi district of Bangladesh. *Int. J.* Geol. Agric. Environ. Sci. 3, 32–38.
BBS, 2013. District Statistics 2011. Bangladesh Bureau of Statistics, Statistics and Informatics Division, Ministry of Planning, Government of the People's Republic of Bangladesh, Rajshahi. http://203.112.218.65:8008/WebTestApplication/userfiles/Image/District%20Statistics/Rajshahi.pdf. (Accessed 15 January 2021).
Boillat, S., Berkes, F., 2013. Perception and interpretation of climate change among Quechua farmers of Bolivia: indigenous knowledge as a resource for adaptive capacity. Ecol. Soc. 18 (4), 21.
Bouchard, M., Laforest, F., Vandelac, L., Bellinger, D., Mergler, D., 2007. Hair manganese and hyperactive behaviors: pilot study of school-age children exposed through tap water. Environ. Health Perspect. 115 (1), 122–127.
Brandt, U.S., Svendsen, G.T., 2013. From global Rio+20 to local agenda 21: is local participation always optimal for sustainable action? J. Environ. Manag. 129, 266–273.
Cheke, R.A., Tratalos, J.A., 2007. Migration, patchiness, and population processes illustrated by two migrant pests. Bioscience 57 (2), 145–154.
Chisanga, K., Mvula, A.B., Habibu, T., 2017. The role of indigenous knowledge in climate adaptation: experiences with farmer perceptions from climate change project in Sedumbwe agricultural camp of southern Zambia. Int. J. Sci. Res. Publ. 7 (9), 94–100.
Dangles, O., Carpio, C., Barragan, A.R., Zeddam, J.L., Silvain, J.F., 2008. Temperature as a key driver of ecological sorting among invasive pest species in the tropical Andes. Ecol. Appl. 18 (7), 1795–1809.
Dey, N.C., Saha, R., Parvez, M., Bala, S.K., Islam, A.S., Paul, J.K., Hossain, M., 2017. Sustainability of groundwater use for irrigation of dry-season crops in Northwest Bangladesh. Groundw. Sustain. Dev. 4, 66–77.
Eriksen, S., Aldunce, P., Bahinipati, C.S., Martins, R.D.A., Molefe, J.I., Nhemachena, C., Ulsrud, K., 2011. When not every response to climate change is a good one: identifying principles for sustainable adaptation. Clim. Dev. 3 (1), 7–20.
FAO, 2007. Climate variability and change: adaptation to drought in Bangladesh A resource book and training guide. http://www.fao.org/3/a1247e/a1247e.pdf. (Accessed 19 June 2021).
FAO, 2016. Women Farmers of Bangladesh. http://www.fao.org/family-farming/detail/en/c/472863/ (accesssed on June 20, 2021).
Hasan, M.A., Islam, A.K.M.S., 2013. Changes of seasonal temperature extremes in future over Bangladesh using projections by a regional climate model. In: National Seminar on Climate Change Impact and Adaptation, pp. 116–120.
Hasan, M.K., Kumar, L., 2020. Perceived farm-level climatic impacts on coastal agricultural productivity in Bangladesh. Clim. Chang. 161, 617–636.
Hossain, N., 2008. Who trusts government? Understanding political trust among the poor in Bangladesh. Asia research institute working paper no. 103. National University of Singapore. https://ssrn.com/abstract=1316782. (Accessed 5 January 2021).
Hossain, M.D., Chowdhury, S., Paul, S.K., 2016. Farmer-level adaptation to climate change and agricultural drought: empirical evidences from the Barind region of Bangladesh. Nat. Hazards 83, 1007–1026.
IPCC, 2014. Climate Change 2014: Impacts, Adaptation, and Vulnerability. http://www.ipcc.ch/report/ar5/wg2/. (Accessed 12 December 2020).
Islam, M.T., Nursey-Bray, M., 2017. Adaptation to climate change in agriculture in Bangladesh: the role of formal institutions. J. Environ. Manag. 200, 347–358.
Islam, A.R.M.T., Tasnuva, A., Sarker, S.C., Rahman, M.M., Mondal, M.S.H., Islam, M.M.U., 2014. Drought in northern Bangladesh: social, agroecological impact and local perception. Int. J. Ecosys. 4 (3), 150–158.
Kurrild-Klitgaard, P., Brandt, U.S., 2021. The calculus of democratic deliberation. Constit. Polit. Econ. 32, 165–186.
Lamiur, R., Onitsuka, D.K., Basu, M., Shimizu, N., Hoshino, S., 2020. Rapid emergence and increasing risks of hailstorms: a potential threat to sustainable agriculture in northern Bangladesh. Sustainability 12, 5011.
Mahmoud, S.H., Adamowski, J., Alazba, A.A., El-Gindy, A.M., 2016. Rainwater harvesting for the management of agricultural droughts in arid and semi-arid regions. Paddy Water Environ. 14 (1), 231–246.
Makondo, C.C., Thomas, D.S., 2018. Climate change adaptation: linking indigenous knowledge with western science for effective adaptation. Environ. Sci. Pol. 88, 83–91.
McNamara, K.E., Buggy, L., 2017. Community-based climate change adaptation: a review of academic literature. Local Environ. 22 (4), 443–460.
OECD, 2013. Trust in Government, policy effectiveness and the governance agenda. Government at a Glance. OECD publishing, pp. 19–37. https://doi.org/10.1787/gov_glance-2013-6-en.
Paul, B.K., 1998. Coping mechanisms practiced by drought victims (1994/95) in North Bengal, Bangladesh. Appl. Geogr. 18 (4), 355–373.
Pelling, M., 2011. Adaptation to Climate Change: From Resilience to Transformation. Routledge, New York.
Pender, J., 2008. Community-led adaptation in Bangladesh. Forced Migr. Rev. 31, 54–55.
Piggott-McKellar, A.E., McNamara, K.E., Nunn, P.D., Watson, J.E., 2019. What are the barriers to successful community-based climate change adaptation? A review of grey literature. Local Environ. 24 (4), 374–390.
Purvis, B., Mao, Y., Robinson, D., 2019. Three pillars of sustainability: in search of conceptual origins. Sustain. Sci. 14 (3), 681–695.
Quaye, W., Fuseini, M., Boadu, P., Asafu-Adjaye, N., 2019. Bridging the gender gap in agricultural development through gender responsive extension and rural advisory services delivery in Ghana. J. Gend. Stud. 28 (2), 185–203.
Ramamasy, S., Bass, S., 2007. Climate Variability and Change: Adaptation to Drought in Bangladesh. FAO, Rome, Italy. http://www.fao.org/3/a-a1247e.pdf. (Accessed 2 March 2021).
Raymond, C.M., Brown, G., 2011. Assessing spatial associations between perceptions of landscape value and climate change risk for use in climate change planning. Clim. Chang. 104 (3–4), 653–678.

Sovacool, B., Ola-Linner, B., 2016. The Political Economy of Climate Change Adaptation. Palgrave, Macmillan, London.
Staley, J.T., Hodgson, C.J., Mortimer, S.R., Morecroft, M.D., Masters, G.J., Brown, V., 2007. Effects of summer rainfall manipulations on the abundance and vertical distribution of herbivorous soil macro-invertebrates. Eur. J. Soil Biol. 43 (3), 189–198.
Sumane, S., Kunda, I., Knickel, K., Strauss, A., Tisenkopfs, T., Des Ios Rios, I., Ashkenazy, A., 2018. Local and farmers' knowledge matters! How integrating informal and formal knowledge enhances sustainable and resilient agriculture. J. Rural. Stud. 59, 232–241.
Taylor, M., 2014. The Political Ecology of Climate Change Adaptation: Livelihoods, Agrarian Change and the Conflicts of Development. Routledge, London.
Tripathi, A., Mishra, A.K., 2017. Knowledge and passive adaptation to climate change: an example from Indian farmers. Clim. Risk Manag. 16, 195–207.
UN, 2020. Sustainable development goals, United Nations Development Programme. https://www.undp.org/content/undp/en/home/sustainable-development-goals.html. (Accessed 5 March 2021).
World Values Survey. http://www.worldvaluessurvey.org, WVS, 2016–. (Accessed 24 February 2021).
Xu, J., Grumbine, R.E., 2014. Integrating local hybrid knowledge and state support for climate change adaptation in the Asian highlands. Clim. Chang. 124 (1–2), 93–104.
Yin, S., Chen, J., Wu, K., Yang, X., 2016. Adaptation of farming households under drought stress: based on a survey in the Minqin oasis. Prog. Phys. Geogr. 35 (5), 644–654.