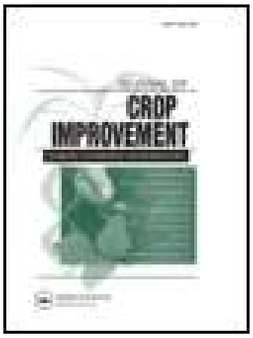

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Potential and challenges of organic agriculture in Bangladesh: a review

Zannatul Ferdous[a,b], Farhad Zulfiqar[c], Avishek Datta [a], Ahmed Khairul Hasan[d], and Asaduzzaman Sarker[e]

[a]Department of Food, Agriculture and Bioresources, School of Environment, Resources and Development, Asian Institute of Technology, Pathum Thani, Thailand; [b]On-Farm Research Division, Bangladesh Agricultural Research Institute, Agricultural Research Station, Rangpur, Bangladesh; [c]Department of Economics, COMSATS University Islamabad, Islamabad, Pakistan; [d]Department of Agronomy, Bangladesh Agricultural University, Mymensingh, Bangladesh; [e]Department of Agricultural Extension and Education, Bangladesh Agricultural University, Mymensingh, Bangladesh

ABSTRACT

Bangladesh's economy and livelihoods of majority of its population depend on agriculture. Despite the importance of agriculture, ensuring food security is a concern because of frequent natural disasters, the effects of climate change, and land degradation. The country has limited land area but diverse ecosystems (hills, plains, coastal, and wetlands). Climatic variations include temperature, rainfall, and humidity. The homestead production system in Bangladesh follows traditional organic farming, with a diversity of fruits, vegetables, spices, and tuber crops. The conventional agriculture in Bangladesh became heavily dependent on synthetic fertilizers and pesticides after the Green Revolution. This has resulted in numerous human health and environmental hazards, compromising food safety. Liberalization and globalization have marginalized small farmers in Bangladesh because of their low bargaining power. Organic agriculture is a potential alternative agricultural production system. It can address human welfare implications of agriculture while ensuring sustainable development. However, the number of farmers practicing organic agriculture and area under organic farming remain small. Therefore, this article provides an overview of the potential of organic farming in Bangladesh by examining the historical development, current state of organic farming, and the bottlenecks in the growth of organic farming. The Bangladeshi model of organic farming development is different from that of the rest of the world, as it is championed by the vibrant local non-governmental organizations (NGOs). The organic agriculture has the potential to become the default production system in Bangladesh, provided the bottlenecks in adoption are addressed, keeping in view the homegrown NGO-backed model of organic agriculture.

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CONTACT Avishek Datta datta@ait.ac.th; avishek.ait@gmail.com Department of Food, Agriculture and Bioresources, School of Environment, Resources and Development, Asian Institute of Technology, Pathum Thani 12120, Thailand

1. Introduction

Before "conventional agriculture" came into practice, organic farming was the way of life for the farming community. Here, organic farming refers to an agricultural production system, wherein only organic inputs are used, excluding all inorganic inputs, such as synthetic pesticides and fertilizers, to achieve sustainable agricultural production (Rasul and Thapa 2003; Samie and Abedullah Ahmed et al. 2010; Singh and George 2012; Zulfiqar and Thapa 2016). In contrast, an agricultural production system highly dependent on synthetic fertilizers, pesticides, and intensive use of water is referred to as "conventional agriculture" (Zulfiqar et al. 2016; Zulfiqar and Thapa 2016). Studies have shown the potential of organic farming for sustainable intensification of agriculture (Forster et al. 2013). There are several potential benefits of organic farming (Altieri 1999; Lyngbaek, Muschler, and Sinclair 2001; Eyhorn, Ramakrishnan, and Mader 2007; Valkila 2009; Mendez et al. 2010; Singh and George 2012; Forster et al. 2013) compared with conventional farming, viz., (i) higher yield stability, (ii) improved soil fertility, (iii) higher yields and profitability, (iv) lower external input use, (v) reclamation of degraded land, (vi) improved market access, and (vii) improved capacity of farmers to use indigenous knowledge and self-reliance in agricultural production (Morshedi et al. 2017). Moreover, soil nutrients in organic crop production can be replenished by using cattle/farmyard manure (Mkhabela 2006; Stepanovic et al. 2016) or by including fodder legumes in crop rotations (Neuhoff et al. 2014). Under organic inputs, soil organic matter can be maintained by the use of plant biomass (David and Ardiansyah 2016). Organic manure can improve soil structure and can also supply essential and trace elements to crops (Stepanovic et al. 2016). It protects crops against variations in temperature, improves germination, increases soil-moisture retention, and creates the right microclimate for soil microorganisms to flourish (Datta et al. 2015; Reddy et al. 2016). Therefore, organic agriculture results in soils that are more resilient to water and nutrient stresses. Moreover, soils under organic farming are better able to control desertification through soil moisture conservation, reduced soil erosion, and increasing soil depth through the application of organic manure (Alam and Wani 2003; Wijitkosum 2020).

By the end of the Second World War, poverty became widespread in many corners of the world, mainly because of poor access to modern technologies, low productivity, and frequent natural calamities (Yoshino 2010). The adoption of "modern" technology resulted in reduced use of physical labor, as the traditional societies shifted agriculture-based activities to manufacturing and services. Consequently, the labor-intensive, low-productivity organic farming got marginalized and stigmatized as being old-fashioned (Yoshino 2010).

Overuse of agrochemicals in the last several decades is partly responsible for certain health problems, environmental degradation, contamination of surface and groundwater, and increased cost of production (Pimentel 1996; Singh 2000; Badgley et al. 2007; Timprasert, Datta, and Ranamukhaarachchi 2014; Ferdous, Datta, and Anwar 2018). Therefore, there is a growing consumer demand worldwide for food produced without the use of synthetic chemicals, and the adoption of organic farming has gained momentum (Abouziena et al. 2009). This growth is also partly supported by attractive premium prices for organic produce (Ramesh, Panwar, and Singh et al. 2010; Panneerselvam et al. 2012).

Despite the penetration of agricultural modernization that started in the early 1960s, organic farming has a higher potential for niche and export markets than conventional farming because of the price premiums. It is grown in certain parts of the world because of its potential to address some important issues, such as environmental degradation and loss of biodiversity (Yoshino 2010). In 2018, the certified agricultural area under organic farming was 71.5 million hectares (mha), covering 1.4% of the global agricultural land (Figure 1). The regions with a relatively large land area under organic

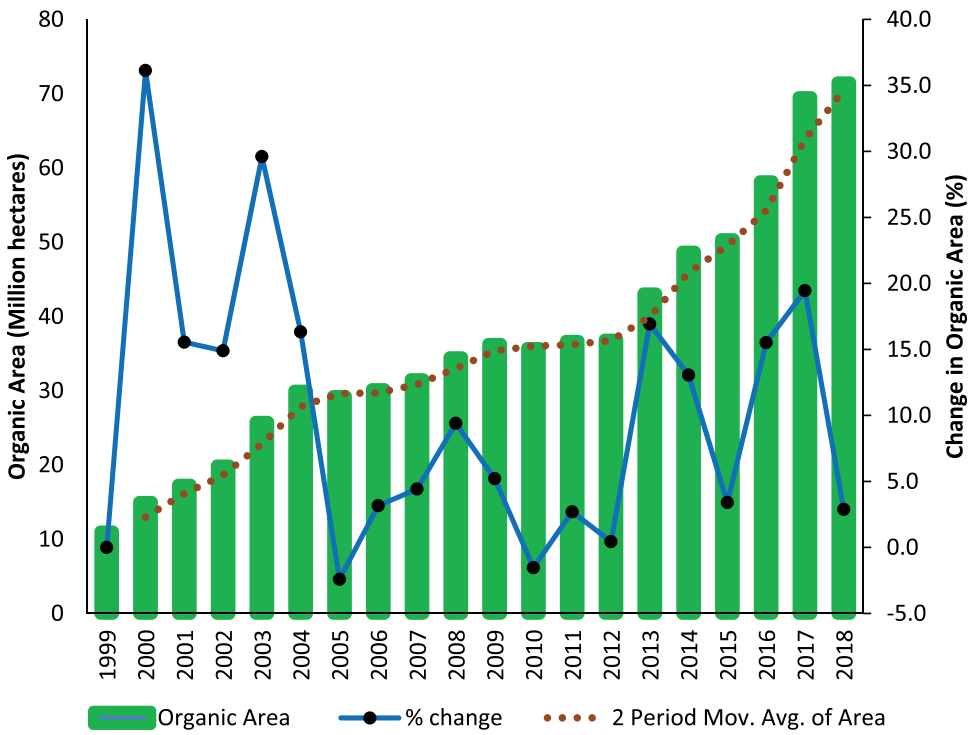

Figure 1. Global growth in the area under organic agriculture and percent change therein during 1999–2018 (Data source: https://statistics.fibl.org/world/area-world.html).

agriculture are Oceania (35.9 mha), Europe (14.6 mha), Latin America (8 mha), and Asia (6.1 mha) (Willer and Lernoud 2019).

However, the ability of organic farming to feed the world remains a controversial issue. Badgley et al. (2007) reported yields of organic agriculture for developed countries to be 92.2% of yields from conventional agriculture vis-à-vis 180.2% for developing countries. This indicates that organic farming could produce enough to feed the world. Some researchers have disputed these findings, however (Connor 2008; de Ponti, Rijk, and van Ittersum 2012). The shift to organic farming requires particular attention to the mandatory transition period. Generally, the minimal transition period is three years and productivity may be affected until the transition from conventional to organic farming is complete (Chase, Delate, and Johanns 2009).

Despite recent growth in organic farming, it remains a minor farming practice. The agricultural area under organic farming and the number of farmers practicing is quite limited. Out of 8.5 mha of cultivable agricultural land, only 8,056 ha (~ 0.1%) was under organic agriculture in Bangladesh (Willer and Lernoud 2019). This small share depicts a huge potential for the expansion of the organic farming area in Bangladesh. Therefore, this article attempts to examine the potential of organic farming by exploring the historical development, the current state of organic farming, major bottlenecks holding back organic agriculture, and policies and strategies needed for expanding the area under organic agriculture in Bangladesh.

2. Organic vs. conventional farming comparison

Organic farming outperforms conventional farming systems in many ways. Organic growers require less credit because of lower external input use, including fertilizers and pesticides (Eyhorn, Ramakrishnan, and Mader 2007). The perceived attitude of lenders against organic growers is, however, non-existent, as researches have shown that real cost and availability of credit was not significantly different for organic farmers vs. conventional farmers (Cacek 1984; Koesling, Ebbesvik, and Lien et al. 2004). Also, organic farms are equally or more profitable compared with conventional farms (Badgley et al. 2007; Panneerselvam, Hermansen, and Halberg 2010). Moreover, organic agriculture provides not only higher productivity but also yield stability through lower use of external inputs, which are particularly critical for marginal locations and in the event of climatic and economic shocks (Panneerselvam, Hermansen, and Halberg 2010). Seufert, Ramankutty, and Foley (2012) reported from a meta-analysis that organic farm yields were comparable to conventional farm yields.

Similarly, a field-level comparison of organic and conventional maize (*Zea mays* L.)-soybean (*Glycine max* (L.) Merr.) systems across a 10-year period

(1991–2001) revealed similar profits for both production systems (Pimentel et al. 2005). In one study, organically grown rice was found to be more economically sustainable compared with conventionally produced rice (Surekha, Rao, and Shobha Rani et al. 2013). A organic cotton (*Gossypium herbaceum* L.)-soybean-wheat (*Triticum aestivum* L.) production system was reported to provide significantly higher gross margins (averaged across all crops) in the second crop cycle in organic farming (+25%) compared with conventional farming (Forster et al. 2013). Moreover, a sustainable agricultural system should combine both yield and environmental sustainability (Reganold and Dobermann 2012). Bangladeshi model of promoting organic farming led by non-governmental organizations (NGOs) can educate farmers about organic practices. Particularly, health benefits to farmers as well as consumers need promotion on a mass scale.

2.1. *Input use in organic farming*

The farming systems in rainfed areas are suited to a lower level of inputs than irrigated areas, with a mixture of integrated livestock farming. The chemical fertilizer use was found to be 18.5 kg in rainfed areas compared with 58 kg in irrigated areas (Katyal and Reddy 1997). Nearly 30% of rainfed farms in India do not use any external chemical inputs, including pesticides and fertilizers, thereby making these regions suitable for organic agriculture (GOI 2001; Ramesh, Singh, and Rao 2005). Ferdous et al. (2016) reported that most of the smallholder farmers in Bangladesh also produced homestead vegetables without using synthetic fertilizers and pesticides. Therefore, organic farming, particularly homesteads, can be the premier system for sustainable food production in Bangladesh. Such a low-input production system will also help reduce the chemical-input import bill of Bangladesh.

3. Global organic market scenario and Bangladesh

Consumer awareness about health and environmental concerns has driven the latest growth in organic food sales: organic market share was US$ 110.25 billion in 2016, which is projected to increase by 138% to reach US$ 262.85 billion by 2022 (TechSci Research 2017). Commercial and certified organic producers are located in 179 countries across Asia, Africa, Australasia, the Pacific, the Caribbean, North America, Central America, South America, and Europe (Willer and Lernoud 2019). At least half of the nations practicing organic farming are developing countries (Jouzi et al. 2017). The position of Bangladesh relative to the top 10 countries in percent area under organic farming in 2017 is shown in Table 1. Bangladesh can seize a substantial share of the future organic market to achieve reduced external costs, market access at a premium price, and reduced risk of crop failure (Jouzi et al. 2017). The

Table 1. Percent area under organic agriculture: top 10 countries and status of Bangladesh as of 2017.

Country	Share of total agricultural land (%)
Liechtenstein	37.9
Samoa	37.6
Austria	24.0
Estonia	20.5
Sweden	18.8
Sao Tome and Principe	18.0
Italy	15.4
Latvia	14.8
Switzerland	14.4
Uruguay	13.0
Bangladesh	0.10

Source: Willer and Lernoud (2019).

organic market has the prospect of reducing poverty by enhancing farmers' income. However, capturing organic market share by Bangladesh requires adherence to organic standards, increasing input-use efficiency, and effective marketing.

As per the latest survey conducted in 2017 by the International Federation of Organic Agriculture Movements (IFOAM), almost 2.9 million producers worldwide are engaged in organic farming (Willer and Lernoud 2019). As the data on certification were not completely reported, the 2.9 million figure is probably an under-estimate. Presently, Liechtenstein, Samoa, and Austria are the top three countries in the area under organic agriculture, with Bangladesh having only 0.1% of land under organic farming (Willer and Lernoud 2019).

4. Historical development and current status of organic farming in Bangladesh

Ganges, Brahmaputra, and Meghna Rivers form a delta in which Bangladesh is situated. Bangladesh has a land area of 147, 570 km^2, with a population of 159 million; about 70% of this population resides in rural areas (FAOSTAT 2016). The average farm household cultivates an area of < 1,000 m^2 (<0.1 ha), and more than 10% of the households have no farmland (Ministry of Agriculture 2010a). High-yielding varieties, intensive irrigation, pesticides, and inorganic fertilizers were introduced in Bangladesh during the Green Revolution in the 1960s. The Green Revolution was further supported by the government through the provision of credit, seeds of high-yielding varieties, and fertilizers. Consequently, the farmers started focusing on conventional rice (*Oryza sativa* L.) monoculture. This production system needs external inputs, such as seed, irrigation, fertilizers, and pesticides, and stable financial resources, which are generally out of the reach of poor smallholders (Jouzi et al. 2017) and the use of some inputs is detrimental to human health and the

environment (Hossain 2012). Before the Green Revolution, farmers used to grow different crops, depending on the hydrological conditions, resulting in stable production. Despite severe floods in Bangladesh in 1988, the agricultural production remained high, which was attributable to the type of rice grown, i.e., *aman* rice, meaning "deep-water rice". The floods increased the soil moisture, favorably affecting the winter crop production (Ando and Uchida 1993). Currently, the dry-season rice area is higher than that of the rainy-season rice, and there is a general increase in the intensity of irrigation, fertilizer, and pesticide use. Also, the diversity of rice varieties has substantially declined; only a few rice varieties are now being cultivated in Bangladesh, as against more than 8,000 rice varieties available in the Gene Bank before the Green Revolution (Tisdell et al. 2019).

Arsenic contamination of groundwater has resulted in severe health hazards in Bangladesh (Brammer and Ravenscroft 2009). Presently, people in about 75% of the districts use arsenic-contaminated drinking water (the arsenic content is higher than the World Health Organization recommended tolerance level) (Chowdhury et al. 2000; Chowdhury, Rahman, and Mondal et al. 2001; Das et al. 2009). The Green Revolution technologies are considered the main reasons for this contamination (Brammer and Ravenscroft 2009).

To control the environmental problems caused by conventional agriculture, NGOs are providing leadership in promoting organic farming in Bangladesh. The Forum for Regenerative Agriculture Movement (FORAM) in Bangladesh has identified 137 organizations interested in sustainable practices. Among these, 47 are involved in organic agriculture, 87 are planning to actively participate in sustainable agriculture, and three are advocating, lobbying, and campaigning for sustainable development. Overall, sustainable agriculture promotion has been led by more than 200 NGOs in Bangladesh (Yoshino 2010; Chakraborty 2018). The "Ecological Agriculture Programme" was initiated in 1978 by PROSHIKA, a pioneer NGO, with the aim of sustainable vegetable production (Sarker and Itohara 2008). This initiative involved 770,000 farmers and 90,000 ha area (Yoshino 2010), of which 220,000 farmers practiced ecological agriculture on 32,374 ha of land during the project period (Sarker and Itohara 2008). Another NGO, UBINIG, which started functioning in 1981, has introduced the "New Agriculture Movement (*Naya Krishi Andolan*)" aimed at controlling the use of synthetic inputs to reduce negative environmental externalities, such as pollution caused by synthetic fertilizers and pesticides, and farmer exploitation. In a sample of 150 contract organic farmers of UBINIG, 98% were found to be food secure (Sarker, Itohara, and Hoque 2009).

4.1. *Government and consumer concerns*

The government's policy, envisaged in 1999 under the National Agriculture Policy, pointed out that the major productivity enhancement hurdle was the

slow adoption of modern technologies by farmers (Ministry of Agriculture 2010b). It stated that for an agricultural system to be sustainable and profitable, it should include integrated pest management as an integral component of crop production. According to the National Agriculture Policy (Ministry of Agriculture 2009), a modern technology-based steady growth rate of 4–4.5% in agriculture was needed to achieve the Millennium Development Goals. However, there has been a lack of concrete policy framework to promote sustainable, organic agriculture.

On the consumer side, Sarker and Itohara (2008) pointed out that nearly 50% of organic food consumers of UBINIG and PROSHIKA were socio-economically affluent. A significant proportion (68%) of these consumers was skeptical about the quality of food at organic shops and 90% felt that organic certification was necessary to ensure quality. Consumers were found to be well aware of the dangers posed by toxicity caused by the use of synthetic chemicals in food production; as such the demand for safe food is high. However, Bangladesh has serious problems attributable to rising toxic chemical use for food production, which ultimately enhances risks to human health (Hossain, Heinonen, and Islam 2008; Tisdell et al. 2019); for example, diseases of skin, eyes, gastrointestinal tract, urinary tract, and reproductive system (Miah et al. 2014; Sumon et al. 2016).

4.2. *Present status of organic farming in Bangladesh*

Bangladesh agriculture predominantly used traditional practices up to 1950. Fertilizers were introduced in Bangladesh in 1959 (Hossain 2012). Thereafter, fossil fuel-based Green Revolution contributed significantly to feeding the burgeoning population through improved agricultural productivity. The average application rate of chemical fertilizer was only 24 kg ha^{-1} during 1965–1970 and it dramatically increased to 160 kg ha^{-1} during 2000–2001 (Bangladesh Bureau of Statistics (BBS) 2007). Similar trends were also observed in pesticide use. Since the beginning of the 21st century, as cropping intensity increased with increased dependence on the synthetic amendment of soil, the soil organic matter content in Bangladesh has declined alarmingly. It has been reported that more than 50% of the cultivated soils in Bangladesh have organic matter content below the critical level of 1.5%, which limits productivity (FRG 2012).

Organic farming provides an alternative, sustainable farming system, but in Bangladesh, it has not captured the attention of common farmers. Willer and Lernoud (2019) documented a total area of 13,903 ha under organic agriculture in Bangladesh in 2017; 8,056 ha land area (about 0.1% of the total agricultural area) was devoted to crops and 5,847 ha to aquaculture. Vegetables, fruits, shrimp, and tea (*Camellia sinensis* L.) are produced organically. The area might be more if the homestead traditional organic practices

are added, which include growing of multiple crops (vegetables, fruits, medicinal plants, and trees) and maintaining livestock and poultry sheds as well as fishponds around the household or within a walking distance of the family home (Ali 2005; Ferdous et al. 2016).

Although organic agricultural production has seen a substantial increase in Bangladesh during the past decade, an area of 8,056 ha constitutes only a small proportion (~ 0.1%) of the total agricultural area, despite a push for more research on and public awareness about organic agriculture (Willer and Lernoud 2019). Higher labor inputs, production, and certification costs; lack of technical know-how and market information; lower yield; and limited demand are the main causes of the smaller organic market in developing countries (Bello 2008; Soltani et al. 2014). Despite the difficulty in mainstreaming organic agriculture, some researchers view it as a main future production system (Pretty 1999; Badgley et al. 2007), while others predict it to remain a marginal production activity (Connor 2008; de Ponti, Rijk, and van Ittersum 2012). The successful experiment of organic farming in Sikkim, India, shows that an organic future is possible (Kumar, Pradhan, and Singh 2018). The organic revolution of Sikkim started when the State adopted a policy of going with organic farming in 2003. Organic farming was promoted in a phased manner. The State has been successful in achieving its organic potential because of the favorable environment, relatively a small cultivable area, and government policy. Bangladesh can learn from the experience of instituting local laws promoting organic agriculture in a phased manner. A country-wide conversion to organic farming may not occur in Bangladesh in the short-run because of its geographical and agro-climatic diversity.

4.3. *Organic market in Bangladesh*

Because of the low purchasing power of people in Bangladesh, they are unable to afford organic food (Hoque 2012). However, there are differences in behavior among the wealthy and health-conscious populace in urban centers (Hossain 2012). This market demand and premium price for organic products have been responsible for the initiation of many organic farming-specific programs. The common organic shops in Bangladesh include Probortana, PROSHIKA, and Meena Bazar. The opposite situation is found in rural areas. Generally, farmers produce organic food for household consumption, keeping it free from all synthetic fertilizers and pesticides and these foods are never marketed. The majority of the marketed organic products are produced through contract farming (Hossain 2012); organic produce sells at a premium price (Iqbal 2015).

Organic agriculture is not only commercially profitable, but it is also sustainable because of reduced resource use (Eyhorn, Ramakrishnan, and Mader 2007; Panneerselvam, Hermansen, and Halberg 2010; Adamtey,

Musyoka, and Zundel et al. 2016). Thus, organic agriculture is actionable for both developing and developed countries because of its potential for socio-economic and environmentally sustainable development (Golijan and Dimitrijević 2018). There is also a great export potential for organic vegetable products from Bangladesh. Although Bangladesh's vegetable exports form only a small share of global vegetable trade, it is growing quite rapidly. During the 15 years from 1995–1996 to 2009–2010, export earnings from this sector increased from US$ 14.5 million to US$ 49.26 million, thereby registering an average annual growth rate of 16% (Bhuyan and Uddin 2010). Bangladesh can tap this potential by producing quality organic products with feedbacks from consumers about their requirements and preferences as well as by seeking inputs from researchers and traders to develop practices that help find creative solutions (Hoffmann, Probst, and Christinck 2007). Hoffmann, Probst, and Christinck (2007) outlined a blueprint of the successful practices of collaboration for innovation as integrating consumers and producers through associations and product linkages. The successful practices included, among others, mutual learning by farmers and researchers with respect to the distinct orientation of each other, and informal experimentation and knowledge building.

4.4. *Scope of organic farming in Bangladesh*

More than 80% of agricultural households in Bangladesh are smallholders, who own < 0.25 ha of cultivable agricultural land and follow an intensive subsistence agriculture (Ferdous et al. 2016). They cultivate various crops, and maintain livestock, poultry, and fishponds in home gardens (Galhena, Freed, and Maredia 2013; Ferdous et al. 2016). These home gardens can be used in the organic production of vegetables and fruits throughout the country and can promote household food self-sufficiency. An increase in the production and productivity of home gardens may be a viable alternative for providing food and nutrition security to poor households of Bangladesh (Ferdous et al. 2016). These home gardens can also be used to enhance household food security, nutrition, and dietary diversity, in addition to increasing household income, employment, and positive environmental externalities by using recycled water and food waste (Weinberger 2013). Farmers can apply organic fertilizers, such as cow dung, poultry manure, compost, kitchen ash, vegetable waste, crop residues, and tree litter, from their own sources to the homestead areas. The use of these organic residues is known to increase fertility, and ultimately the productivity of home gardens (Galhena, Mikunthan, and Maredia 2012; Ansari et al. 2016). Pests can be controlled organically by selecting varieties with improved tolerance/resistance to biotic stresses, applying biological agents, sex pheromones, biopesticides (plant extracts), light traps (Timprasert, Datta, and Ranamukhaarachchi 2014; Ferdous, Datta, and Anwar 2018), and using mechanical means without any

pesticide application, such as mound digging or food traps (Mamun and Ahmed 2011). These homesteads can provide a stable supply of vegetables, particularly to marginal rural communities, improving their vitamin and mineral intake. Therefore, food policies encouraging the production in homestead gardens have the potential to increase food security, food nutrition, and women empowerment (Ferdous et al. 2016). The government project of "one-house-one-farm" (Rahman and Islam 2014), which started in 2009, is a step in the right direction for achieving these goals through homestead farming.

4.5. *Organic farming research in Bangladesh*

The research conducted in Bangladesh has shown the superiority of organic farming over conventional farming (Uddin, Dhar, and Islam 2016). The agricultural yield growth from conventional farming has plateaued and could decline further (Karim 2018; Tisdell et al. 2019). There are various factors affecting the adoption of organic agriculture in Bangladesh. These factors include knowledge and awareness among farmers about ecological and health concerns, ease of application of organic farming technologies, and input availability (Sarker 2010). Thus, farmer-focused practices in organic farming are more likely to be mass adopted if the needed inputs are available when required. Also, because conventional rice production is becoming increasingly less profitable because of mounting costs, organic farming may provide a viable cost-effective alternative (Jouzi et al. 2017). Lower input requirements of organic farming than conventional farming and similar productivity, coupled with price premiums, make organic production suitable for smallholders in Bangladesh. The social and environmental benefits of organic farming over conventional farming include equitable opportunities as well as lower chemical release in the groundwater and atmosphere (Karim 2018). Researchers have long advocated the adoption of ecologically sustainable agriculture in Bangladesh (Kabir, Haque, and Uddin et al. 2007).

Ferdous, Datta, and Anwar (2017) conducted a study on indigenous microorganisms (IMOs), indicating that IMOs produced more fruit per plant in tomato (*Solanum lycopersicum* L.) compared with plants grown without IMOs. The authors reported a 17% yield improvement in IMO-treated plots compared with plots without IMO in the coastal region of Bangladesh. However, the limited availability of public extension system is holding back the mass adoption of organic farming in Bangladesh (Dhar et al. 2018; Ghosh et al. 2019). In addition, the conversion to organic farming is hindered by ineffective communication of modern organic practices to farmers by researchers and government extension network. Thus, a concerted effort by the government extension system, backed by research-based evidence on organic farming, to promote organic farming will be instrumental in mass adoption by farmers in Bangladesh.

4.6. Research gap and future research scope in Bangladesh

The initial direction of the country toward organic farming was set by PROSHIKA in 1978, with the aim of sustainable vegetable production (Sarker and Itohara 2008). However, a systematic research-based evidence on organic farming was initiated by the Bangladesh Agricultural Research Institute only as recently as 2006 (Uddin, Ahmed, and Halim 2011; Musa, Bokhtiar, and Gurung 2015). Since then, various researchers have assessed the economic, social, and environmental benefits of organic farming in Bangladesh (Uddin, Dhar, and Islam 2016; Karim 2018; Tisdell et al. 2019). In addition, they have assessed the possible factors influencing the adoption of organic farming in Bangladesh (Kabir, Haque, and Uddin et al. 2007; Sarker 2010) and have highlighted the positive role of NGOs in promoting organic farming in Bangladesh. However, research is lacking on the potential combined role of NGOs, farmers, and government extension system. The participation of these three main stakeholders in organic research and its promotion can be transformative for organic farming in Bangladesh. Although the presence of the public extension system is ubiquitous in Bangladesh, it has not been successful in effectively communicating the benefits of organic agriculture to the farmers. A participatory approach to experimentation, along with research and technology development, will improve organic adoption, as it has been shown to improve knowedge delivery to farmer (Hoffmann, Probst, and Christinck 2007). Thus, this research gap on the collective role of NGOs, farmers, and government agencies needs to be investigated, along with the role of modern information and communication technologies in providing organic technologies at farmers' doorsteps. The potential contribution of agricultural modeling techniques and geographical mapping for displaying the suitability of organic farming is also an avenue for future research in Bangladesh.

5. Adoption of organic farming in Bangladesh

The decision on the adoption of organic farming is dependent on farmers' perceptions regarding its socioeconomic and environmental sustainability (Rigby and Cáceres 2001; Elzen and Wieczorek 2005). Farmers have positive perceptions about the potential of organic farming for increased income, safe food, and reduced negative environmental impacts (Uddin et al. 2016). Farmers have experienced benefits of organic farming in the form of lower external chemical input use, leading to lower production costs, price premiums, and eventually higher profits.

Public extension in Bangladesh promotes integrated pest management as an important component of organic farming. As the availability of manual labor is a major constraint in organic farming adoption, larger households

have a higher probability of adopting organic farming (Sarker and Itohara 2008). Feder, Just, and Zilberman (1985) reported that the labor-intensive technologies were more suitable to larger family structure because of more labor availability.

Farmers' adoption of any innovation depends on their farm objectives, whereby they try to maximize their utility subject to constraints. The utility refers to the satisfaction achieved by accomplishing one's objective (McConnell, Brue, and Flynn 2018). The adoption models have shown that those practices have a better chance of being adopted that increase farmers' utility, profitability, or reduce the risks in production (Feder, Just, and Zilberman 1985; Zulfiqar et al. 2016; Zulfiqar and Thapa 2018). The utility, in turn, depends on the improvements in yield or cost minimization. The farmers tend to switch to new technologies when such technologies offer increased profits through increased output or reduced production costs (Feder, Just, and Zilberman 1985; Zulfiqar and Thapa 2018). Various researchers have regarded health, environment, food security, and consideration of risks as important components of farmers' utility decisions (Ribaudo 1998; Napier, Tucker, and McCater 2000; Uddin et al. 2016). Thus, dissemination of information about higher profitability of organic farming compared with conventional farming among farmers can increase the adoption of organic practices. Moreover, the health and environmental benefits of organic farming can further attract farmers to the organic movement.

5.1. *Bottlenecks in organic farming growth in Bangladesh*

Generally, since the start of its promotion, organic farming in Bangladesh has been faced with recurrent problems, such as lower cropping intensity in organic farming than in conventional farming, lack of credit availability to farmers, land tenancy issues, poor economic status of farmers, farmers' limited knowledge base, farmers' access to critical inputs, and market access for sale of organic output (Sarker and Itohara 2008; Hossain 2012). As these problems apply to the whole sector, the solutions must also come collectively. A model of cooperation, where farmers participate in group activities has already been suggested by Sarker and Itohara (2008). This model is based on establishing a cooperative-based structure to address many of the aforementioned problems. However, this model did not materialize because of the limited education of farmers and lack of infrastructure and policy support from the government.

In Bangladesh, there have been various attempts of enhancing cooperation in organic farming by the NGOs (Rahman 2001). UBINIG, one of the leading NGOs of the country, developed a radical, community-based approach to organic farming, which is referred to as *Naya Krishi Andolan* (New Agriculture Movement). The major features of the *Naya Krishi Andolan*

are group formation and regular meetings, awareness and motivational campaign in rural communities, community-based preservation of genetic and natural resources, integrating animal husbandry and aquaculture into farming, increasing women participation in agriculture, and incorporating cultural values into farming. A unique feature of the *Naya Krishi Andolan* is that instead of an individual approach, it adopts a strategy of community-based approach; the goal is to effect the change in the entire rural community (UBINIG 2003). The *Naya Krishi Andolan* has substantially increased its reach in Bangladesh by engaging more than 170,000 farm households. The *Naya Krishi Andolan* activities, which are coordinated by UBINIG, are assumed to increase networking (through organization building, cooperation with consumer groups, and working with civil society), norms of cooperation (through community-based seed and forestry resource preservation, exchange of organic inputs, regular extension sessions, cultural and folk events, coordinated marketing), and trust (through group-based control and monitoring).

Similar to most developing countries, where agriculture sector is significant for economic growth and poverty reduction, agriculture serves as the backbone of the economy in Bangladesh. However, depletion of soil nutrients and organic matter, along with soil erosion, hampers sustainable agricultural output (Ministry of Agriculture 2008). Despite a manifold increase in the use of fertilizers (Ministry of Agriculture 2008) and pesticides (Ministry of Agriculture 2005), agricultural productivity has not increased as quickly. The major beneficiaries of this pesticide use have been vegetables and *boro* rice (dry winter season rice) (UNDP 2006). The use of fertilizers and pesticides is disproportionately high (Bangladesh Bureau of Statistics (BBS) 2008), implying a general overuse of agrochemicals. Bangladesh, being a net importer of agrochemicals, incurs import costs of agrochemicals, which are eventually misused. Therefore, organic farming provides an excellent avenue for both environmental protection and resource conservation in Bangladesh (Faroque, Kashem, and Bilkis 2013).

Because of the aforementioned negative externalities caused by agrochemical overuse, sustainable agricultural development requires policy interventions to ensure optimal input use, preferably from domestic resources. Organic farming aptly fills this gap because of its inherent minimal external chemical input use and environmental footprint, and cost-effectiveness (Vogl, Kilcher, and Schmidt 2005; Uddin et al. 2016).

In Bangladesh, the farmers associated with PROSHIKA and the Bangladesh Agricultural Research Institute apply cow dung, vermicompost, and fermented plant extract as organic fertilizer. Household waste, including organic waste and gardening waste, such as from *Sesbania*, and tree leaves, are other forms of green manures used by organic farmers. Other initiatives, such as *Naya Krishi Andolan*, also actively promote these

practices. Farming-household women are encouraged to use organic household waste for composting. Animal waste, such as dung from dairy animals, has long been used for composting in Kazi and Kazi Tea Estate (Hoque 2012).

6. Schematic framework of organic farming in Bangladesh

The historical development of organic farming, present status, and future direction, along with the factors that influence them, are summarized in Figure 2. The historical development of organic agriculture came from a global push for organic farming as a result of various negative economic, social, and environmental consequences of conventional farming. The world also witnessed an increased interest in organic farming because of Millennium Development Goals and later Sustainable Development Goals (SDGs). Goal number 12 of SDGs, responsible consumption and production, relates to the promotion of sustainable agricultural production practices, such as organic agriculture. The Bangladeshi model for the promotion of organic farming differed from the global model, as NGOs took the lead in advancing organic farming in the country instead of public or private institutions.

The positive and negative effects of various factors on organic farming are also listed in Figure 2. As climate change affects agricultural production, agricultural productivity is expected to be reduced by 5–17% in rice, wheat, and other grain crops by 2030 (Bandara and Cai 2014); this would include organic farming systems also. Other factors negatively affecting the present and future organic farming in Bangladesh include farmers' limited credit access, land title issues, poor economic status of farmers, limited knowledge base, limited organic input availability, and output market access to farmers. Farmers have positive perceptions of organic farming potential but are presently reluctant to adopt organic farming because of various bottlenecks. However, this is expected to change if the government policies are favorable and access of farmers to various institutional services, especially extension, is ensured.

The positive effects, contributing to present organic farming adoption, are consumers' regard for food safety and premium prices of organic produce received by the farmers. The future of organic farming is expected to be bright because of the export potential of organic products, homestead production, and increased domestic demand, given the increasing incomes and population.

The historical, present, and future prospects of organic farming can only be aligned if a favorable way forward is followed. It requires favorable government policies, research institutions developing organic methods of pest control, improved access to institutional services, including extension, credit, and input-output markets, following homegrown NGO-led organic

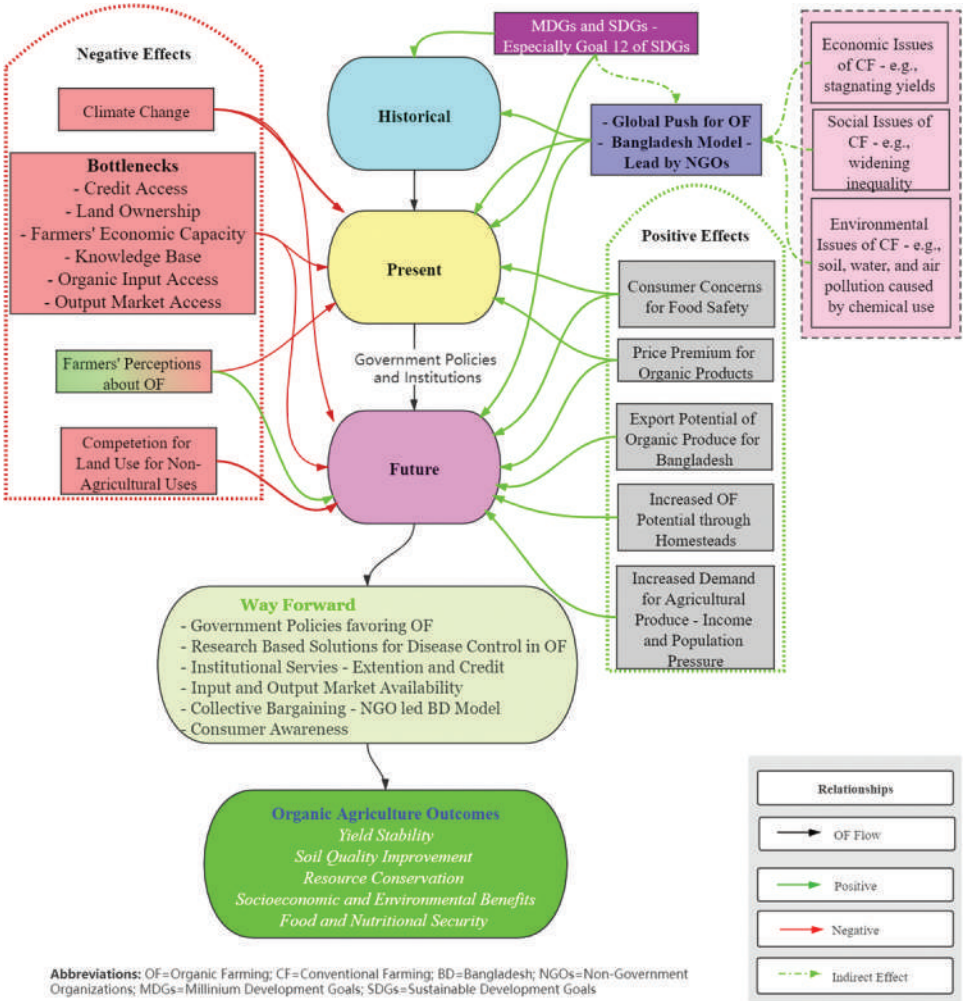

Figure 2. Schematic framework of organic farming in Bangladesh.

promotion model, and programs for raising consumer awareness of organic products. This way forward will lead us to an organic agriculture outcome where we see yield stability, soil preservation, resource conservation, numerous socioeconomic and environmental benefits, and ultimately food and nutritional security of the masses.

7. Summary

Organic farming has the potential to fulfill the promise of ecologically efficient and socioeconomically desirable agriculture. The export markets

and price premiums for organic products make it an even more attractive prospect. However, this unfulfilled potential is visible from just 1.2% of global agricultural land being under organic farming, representing a US$ 97 billion market capture, and Bangladesh may focus on capturing a part of this huge market. Organic farming makes up just 0.1% of the arable land area of Bangladesh. The increase in area is the result of public awareness about the hazards of conventional agriculture and a leadership role being played by various NGOs in Bangladesh. The Bangladeshi model of organic agriculture promotion involves the role of local NGOs.

Organic products are demanded by Bangladeshi consumers, as evidenced by the high demand for products marketed by UBINIG and PROSHIKA, despite the price premiums. Apart from the domestic demand, exports have seen a manifold increase in the organic produce. This high demand can be easily met by Bangladeshi farmers and homesteads. Most Bangladeshi farmers are small farmers and organic practices are easier to implement at a small scale. Thus, government food policies promoting organic farming can do wonders for improving food and nutritional security in Bangladesh.

The research has shown that organic farming is viable in Bangladesh. Unlike conventional farming, organic farming is sustainable economically, socially, and environmentally. The impediments in adoption of organic farming are lack of knowledge and awareness about ecological and health concerns, limited understanding of organic farming technologies, and inadequate input availability. The other bottlenecks include credit and organic input accessibility, land ownership, and farmers' access to market to sell their organic produce.

8. Conclusion

The present agricultural policy of Bangladesh aims to improve agricultural production through optimal resource utilization, and removal of bottlenecks. The realization of such a policy requires agricultural transition by shifting focus toward agroecology and sustainability. This requires a comprehensive policy package encompassing all aspects of agriculture, including input and output markets, agro-based industrial policy, and environmental considerations. The policymakers need to be convinced that organic farming provides a solution to the problems created by conventional agriculture because of its sustainable nature. The implementation of organic farming at a large scale requires mass conversion to it, which may cause food security issues because of productivity concerns during the transition period, along with the effects of climate change. Other pertinent concerns include women participation, food wastage, field-based evidence, societal access to healthy food, institutional support during the conversion period, and premium price for organic produce.

Bangladesh has a potential market for organic vegetables because of changing consumer preferences. Organic vegetables provide a win-win solution to consumers and producers – producers receive higher returns and consumers receive safe food. Therefore, the promotion of sustainable organic production requires collaboration among various government departments, strengthening of farmers' capacity through training, raising awareness among consumers, and development of policies in favor of organic agriculture. Moreover, chemical-residue-free and safe food products can improve food security and food safety of the people of Bangladesh. Lastly, it should be noted that women can play an important role in organic farming. UBINIG's activities provide a blueprint for a mutually beneficial relationship, whereby women receive capacity building trainings on organic farming, which ensures their increased role in the society.

Disclosure statement

No potential conflict of interest was reported by the authors.

ORCID

Avishek Datta http://orcid.org/0000-0002-5575-2766

References

Abouziena, H. F. H., A. A. M. Omar, S. D. Sharma, and M. Singh. 2009. "Efficacy Comparison of Some New Natural-product Herbicides for Weed Control at Two Growth Stages." *Weed Technology* 23: 431–437. doi:10.1614/WT-08-185.1.

Adamtey N, Musyoka MW, Zundel C, Cobo JG, Karanja EK, Fiaboe KKM, Muriuki AW, Mucheru-Muna M, Vanlauwe B, Berset E, Messmer MM, Gattinger A, Bhullar GS, Cadisch G, Fliessbach A, Mäder P, Niggli U, Foster D. 2016. "Productivity, Profitability and Partial Nutrient Balance in Maize-based Conventional and Organic Farming Systems in Kenya." *Agriculture, Ecosystems & Environment* 235:61–79.

Alam, A., and S. A. Wani. 2003. *Status of Organic Agriculture worldwide–An Overview. Proceedings of National Seminar on Organic Products and Their Future Prospects*, 95–103. Srinagar, India: Sher-e-Kashmir University of Agricultural Sciences and Technology.

Ali, A. M. S. 2005. "Homegardens in Smallholder Farming Systems: Examples from Bangladesh." *Human Ecology* 33: 245–270. doi:10.1007/s10745-005-2434-8.

Altieri, M. A. 1999. "The Ecological Role of Biodiversity in Agroecosystems." *Agriculture, Ecosystems & Environment* 74: 19–31. doi:10.1016/S0167-8809(99)00028-6.

Ando, K., and H. Uchida. 1993. "Characteristics of Traditional Rice Production." In *More to Know Bangladesh (Motto Shiritai Bangladesh)*, 20–36. Kobundo, Tokyo, Japan, pp. 20–36.

Ansari, A. A., S. Jaikishun, M. A. Islam, S. K. Kuri, K. Fiedler, and D. Nandwani. 2016. "Principles of Vermitechnology in Sustainable Organic Farming with Special Reference to Bangladesh." In *Organic Farming for Sustainable Agriculture. Sustainable Development and Biodiversity*, edited by D. Nandwani, 213–229. Vol. 9. Switzerland: Springer International Publishing.

Badgley, C., J. Moghtader, E. Quintero, E. Zakem, M. J. Chappell, K. Avilés-Vázquez, A. Samulon, and I. Perfecto. 2007. "Organic Agriculture and the Global Food Supply." *Renewable Agriculture and Food Systems* 22: 86–108. doi:10.1017/S1742170507001640.

Bandara, J. S., and Y. Cai. 2014. "The Impact of Climate Change on Food Crop Productivity, Food Prices and Food Security in South Asia." *Economic Analysis and Policy* 44: 451–465. doi:10.1016/j.eap.2014.09.005.

Bangladesh Bureau of Statistics (BBS). 2007. *Planning Division*. Ministry of Planning, Government of the People's Republic of Bangladesh, Dhaka, Bangladesh.

Bangladesh Bureau of Statistics (BBS). 2008. *Planning Division*. Ministry of Planning, Government of the People's Republic of Bangladesh, Dhaka, Bangladesh.

Bello, W. B. 2008. "Problems and Prospect of Organic Farming in Developing Countries." *Ethiopian Journal of Environmental Studies and Management* 1: 36–43. doi:10.4314/ejesm.v1i1.41568.

Bhuyan, M. A. J., and M. N. Uddin 2010. "Present Status and Improvement Strategy of Vegetables Crops through Regional Trials." Regional workshop on 'Improvement of Vegetables and Adaptive Trials in SAARC Countries', Hotel Sheraton, Dhaka, Bangladesh, September 8–9.

Brammer, H., and P. Ravenscroft. 2009. "Arsenic in Groundwater: A Threat to Sustainable Agriculture in South and South-east Asia." *Environment International* 35: 647–654. doi:10.1016/j.envint.2008.10.004.

Cacek, T. 1984. "Organic Farming: The Other Conservation Farming System." *Journal of Soil and Water Conservation* 39: 357–360.

Chakraborty, A. 2018. *Prospects and Challenges of Organic Farming in Bangladesh*. Gazipur, Bangladesh: Department of Environmental Science, Bangabandhu Sheikh Mujibur Rahman Agricultural University.

Chase, C., K. Delate, and A. Johanns. 2009. *Making the Transition from Conventional to Organic*. Ames, IA, USA: Coop. Ext. Bull. PM-2073, Iowa State Univ.

Chowdhury, U. K., B. K. Biswas, T. R. Chowdhury, G. Samanta, B. K. Mandal, G. C. Basu, C. R. Chanda, et al. 2000. "Groundwater Arsenic Contamination in Bangladesh and West Bengal, India." *Environmental Health Perspectives* 108: 393–397. doi:10.1289/ehp.00108393.

Chowdhury UK, Rahman MM, Mondal BK, Paul K, Lodh D, Biswas BK, Basu GK. et al. 2001. "Groundwater Arsenic Contamination and Human Suffering in West Bengal, India and Bangladesh." *Environmental Science* 8:393–415.

Connor, D. J. 2008. "Organic Agriculture Cannot Feed the World." *Field Crops Research* 106: 187–190. doi:10.1016/j.fcr.2007.11.010.

Das, B., M. M. Rahman, B. Nayak, A. Pal, U. K. Chowdhury, S. C. Mukherjee, K. C. Saha, S. Pati, Q. Quamruzzaman, and D. Chakraborti. 2009. "Groundwater Arsenic Contamination, Its Health Effects and Approach for Mitigation in West Bengal, India and Bangladesh." *Water Quality, Exposure and Health* 1: 5–21. doi:10.1007/s12403-008-0002-3.

Datta, A., S. Shrestha, Z. Ferdous, and C. C. Win. 2015. "Strategies for Enhancing Phosphorus Efficiency in Crop Production Systems." In *Nutrient Use Efficiency: From Basics to Advances*, edited by A. Rakshit, H. B. Singh, and A. Sen, 59–71. Springer, New Delhi. ISBN 978-81-322-2169-2. Accessed 26 July 2020. doi: 10.1007/978-81-322-2169-2_5.

David, W., and Ardiansyah. 2016. "Organic Agriculture in Indonesia: Challenges and Opportunities." *Organic Agriculture* 7: 329–338. doi:10.1007/s13165-016-0160-8.

de Ponti, T., B. Rijk, and M. K. van Ittersum. 2012. "The Crop Yield Gap between Organic and Conventional Agriculture." *Agricultural Systems* 108: 1–9. doi:10.1016/j.agsy.2011.12.004.

Dhar, A. R., M. M. Islam, A. Jannat, and J. U. Ahmed. 2018. "Adoption Prospects and Implication Problems of Practicing Conservation Agriculture in Bangladesh: A

Socioeconomic Diagnosis." *Soil and Tillage Research* 176: 77–84. doi:10.1016/j.still.2017.11.003.

Elzen, B., and A. Wieczorek. 2005. "Transitions Towards Sustainability through System Innovation." *Technological Forecasting and Social Change* 72: 651–661. doi:10.1016/j.techfore.2005.04.002.

Eyhorn, F., M. Ramakrishnan, and P. Mader. 2007. "The Viability of Cotton-based Organic Farming Systems in India." *International Journal of Agricultural Sustainability* 5: 25–38. doi:10.1080/14735903.2007.9684811.

FAOSTAT. 2016. *FAO Online Statistical Database on Annual Population Estimation and Year of Projection*. Rome, Italy: FAO. Accessed 18 September 2019. http://faostat3.fao.org/download/O/OA/E.

Faroque, M., M. Kashem, and S. Bilkis. 2013. "Sustainable Agriculture: A Challenge in Bangladesh." *International Journal of Agricultural Research, Innovation and Technology* 1: 1–8. doi:10.3329/ijarit.v1i1-2.13922.

Feder, G., R. E. Just, and D. Zilberman. 1985. "Adoption of Agricultural Innovations in Developing Countries: A Survey." *Economic Development and Cultural Change* 33: 255–298. doi:10.1086/451461.

Ferdous, Z., A. Datta, A. K. Anal, M. Anwar, and M. R. Khan. 2016. "Development of Home Garden Model for Year Round Production and Consumption for Improving Resource-poor Household Food Security in Bangladesh." *NJAS - Wageningen Journal of Life Sciences* 78: 103–110. doi:10.1016/j.njas.2016.05.006.

Ferdous, Z., A. Datta, and M. Anwar. 2017. "Plastic Mulch and Indigenous Microorganism Effects on Yield and Yield Components of Cauliflower and Tomato in Inland and Coastal Regions of Bangladesh." *Journal of Crop Improvement* 31: 261–279. doi:10.1080/15427528.2017.1293578.

Ferdous, Z., A. Datta, and M. Anwar. 2018. "Synthetic Pheromone Lure and Apical Clipping Affects Productivity and Profitability of Eggplant and Cucumber." *International Journal of Vegetable Science* 24: 180–192. doi:10.1080/19315260.2017.1407858.

Forster, D., C. Andres, R. Verma, C. Zundel, M. M. Messmer, and P. Mader. 2013. "Yield and Economic Performance of Organic and Conventional Cotton-based Farming Systems – Results from a Field Trial in India." *Plos One* 8: e81039. doi:10.1371/journal.pone.0081039.

FRG. 2012. *Fertilizer Recommendation Guide*, 1215. Farmgate, Dhaka: Bangladesh Agricultural Research Council, BARC.

Galhena, D. H., R. Freed, and K. Maredia. 2013. "Home Gardens: A Promising Approach to Enhance Household Food Security and Wellbeing." *Agriculture and Food Security* 2: 8.

Galhena, D. H., G. Mikunthan, and K. M. Maredia. 2012. "Home Gardens for Enhancing Food Security in Sri Lanka." *Farming Matters* 28: 12.

Ghosh, M. K., M. H. Sohel, N. Ara, F. T. Zahara, S. B. Nur, and M. M. Hasan. 2019. "Farmers Attitude Towards Organic Farming: A Case Study in Chapainawabganj District." *Asian Journal of Advances in Agricultural Research* 10: 1–7.

GOI. 2001. *The Report of the Working Group on Organic and Biodynamic Farming*, 1–25. Planning Commission, New Delhi, Government of India, pp. 1–25.

Golijan, J., and B. Dimitrijević. 2018. "Global Organic Food Market." *Acta agriculturae Serbica* 23: 125–140. doi:10.5937/AASer1846125G.

Hoffmann, V., K. Probst, and A. Christinck. 2007. "Farmers and Researchers: How Can Collaborative Advantages Be Created in Participatory Research and Technology Development? Agric." *Agriculture and Human Values* 24: 355–368. doi:10.1007/s10460-007-9072-2.

Hoque, M. N. 2012. *Eco-friendly and Organic Farming in Bangladesh – International Classification and Local Practice. GEB-IDN/8778*. Germany: Institute of Rural Sociology and Extension, University of Giessen.

Hossain, M. M., V. Heinonen, and K. M. Z. Islam. 2008. "Consumption of Foods and Foodstuffs Processed with Hazardous Chemicals: A Case Study of Bangladesh." *International Journal of Consumer Studies* 32: 588–595. doi:10.1111/j.1470-6431.2008.00690.x.

Hossain, S. T. 2012. "Organic Farming in Populated Area: Bangladesh – An Example of Case Study." In *Organic Farming in Populated Area: Bangladesh – An Example of Case Study*, 105–113. Accessed 12 July 2019. http://orgprints.org/29203/2/29203.pdf

Iqbal, M. 2015. "Consumer Behavior of Organic Food: A Developing Country Perspective." *International Journal of Bus Communication Systems* 4: 59–68.

Jouzi, Z., H. Azadi, F. Taheri, K. Zarafshani, K. Gebrehiwot, S. Van Passel, and P. Lebailly. 2017. "Organic Farming and Small-scale Farmers: Main Opportunities and Challenges." *Ecological Economics* 132: 144–154. doi:10.1016/j.ecolecon.2016.10.016.

Kabir MS, Haque ME, Uddin MM, Samsuddula AM, Sarker MMH. 2007. "Constraints of Adopting Eco-friendly Rice Farming Practices." *Journal of Innovation and Development Strategy* 1:6–11.

Karim, M. R. 2018. "Prospects of Organic Farming for Sustainable Agriculture and Climate Change Mitigation in Bangladesh." *SciFed Journal of Global Warming* 2: 2.

Katyal, J. C., and K. C. K. Reddy. 1997. "Plant Nutrient Supply Needs: Rainfed Crops." In *Plant Nutrient Needs, Supply, Efficiency and Policy Issues: 2000–2025*, edited by S. S. Kanwar and J. C. Katyal, 91–113. New Delhi, India: National Academy of Agricultural Sciences.

Koesling M, Ebbesvik M, Lien G, Flaten O, Valle PS, Arntzen H. 2004. "Risk and Risk Management in Organic and Conventional Cash Crop Farming in Norway." *Acta Agriculturae Scandinavica, Section C — Food Economics* 1:195–206.

Kumar, J., M. Pradhan, and N. Singh. 2018. "Sustainable Organic Farming in Sikkim: An Inclusive Perspective." In *Advances in Smart Grid and Renewable Energy. Lecture Notes in Electrical Engineering*, edited by G. S. Sen, A. Zobaa, K. Sherpa, and A. Bhoi. Vol. 435. Singapore: Springer.

Lyngbaek, A. E., R. G. Muschler, and F. L. Sinclair. 2001. "Productivity and Profitability of Multistrata Organic versus Conventional Coffee Farms in Costa Rica." *Agroforestry Systems* 53: 205–213. doi:10.1023/A:1013332722014.

Mamun, M. S. A., and M. Ahmed. 2011. "Integrated Pest Management in Tea: Prospects and Future Strategies in Bangladesh." *Journal of Plant Protection Sciences* 3: 1–13.

McConnell, C. R., S. L. Brue, and S. M. Flynn. 2018. *Microeconomics: Principles, Problems, and Policies*. 21st ed. NY, USA: McGraw-Hill Education.

Mendez, V. E., C. M. Bacon, M. Olson, S. Petchers, D. Herrador, C. Carranza, L. Trujillo, et al. 2010. "Effects of Fair Trade and Organic Certifications on Small-scale Coffee Farmer Households in Central America and Mexico". . *Renewable Agriculture and Food Systems* 25: 236–251. doi:10.1017/S1742170510000268.

Miah, S. J., A. Hoque, A. Paul, and A. Rahman. 2014. "Unsafe Use of Pesticide and Its Impact on Health of Farmers: A Case Study in Burichong Upazila, Bangladesh." *Journal of Environmental Science, Toxicology and Food Technology* 8: 57–67.

Ministry of Agriculture. 2005. *Trends of Pesticides Consumption in Bangladesh. A Booklet*. Plant Protection Wing of the Department of Agricultural Extension, Ministry of Agriculture, Government of the People's Republic of Bangladesh, Dhaka, Bangladesh.

Ministry of Agriculture. 2008. *National Agriculture Policy (Draft 3)*. Ministry of Agriculture, Government of the People's Republic of Bangladesh, Dhaka, Bangladesh.

Ministry of Agriculture. 2009. *National Agriculture Policy (Draft 5)*. Ministry of Agriculture, Government of the People's Republic of Bangladesh, Dhaka, Bangladesh.

Ministry of Agriculture. 2010a. *Handbook of Agricultural Statistics, December 2007*. Ministry of Agriculture, Government of the People's Republic of Bangladesh, Dhaka, Bangladesh.

Ministry of Agriculture. 2010b. *National Agriculture Policy (NAP)*. Ministry of Agriculture, Government of the People's Republic of Bangladesh, Dhaka, Bangladesh.

Mkhabela, T. S. 2006. "A Review of the Use of Manure in Smallscale Crop Production Systems in South Africa." *Journal of Plant Nutrition* 29: 1157–1185. doi:10.1080/01904160600767179.

Morshedi, L., F. Lashgarara, S. J. F. Hosseini, and M. O. Najafabadi. 2017. "The Role of Organic Farming for Improving Food Security from the Perspective of Fars Farmers." *Sustainability* 9 (11): 2086.

Musa, M., S. M. Bokhtiar, and T. R. Gurung, Eds. 2015. *Status and Future Prospect of Organic Agriculture for Safe Food Security in SAARC Countries*. Farmgate, Dhaka-1215, Bangladesh: SAARC Agriculture Centre (SAC), BARC Complex.

Napier, T. L., M. Tucker, and S. McCater. 2000. "Adoption of Conservation Tillage Production Systems in Three Midwest Watersheds." *Journal of Soil and Water Conservation* 55: 123–134.

Neuhoff D, Tashi S, Rahmann G, Denich M. 2014. "Organic Agriculture in Bhutan: Potential and Challenges". *Organic Agriculture* 4: 209–221. doi:10.1007/s13165-014-0075-1.

Panneerselvam P, Halberg N, Vaarst M, Hermansen JE. 2012. "Indian Farmer's Experience with Perceptions of Organic Farming". . *Renewable Agriculture and Food Systems* 27: 157–169. doi:10.1017/S1742170511000238.

Panneerselvam, P., J. Hermansen, and N. Halberg. 2010. "Food Security of Small Holding Farmers: Comparing Organic and Conventional Systems in India." *Journal of Sustainable Agriculture* 35: 48–68. doi:10.1080/10440046.2011.530506.

Pimentel, D. 1996. "Green Revolution Agriculture and Chemical Hazards." *Science of the Total Environment* 188: S86–S98. doi:10.1016/0048-9697(96)05280-1.

Pimentel D, Hepperly P, Hanson J, Douds D, Seidel R. 2005. "Environmental, Energetic and Economic Comparisons of Organic and Conventional Farming Systems". *BioScience* 55: 573–582. doi:10.1641/0006-3568(2005)055[0573:EEAECO]2.0.CO;2.

Pretty, J. 1999. "Can Sustainable Agriculture Feed Africa? New Evidence on Progress, Processes and Impacts." *Environment, Development and Sustainability* 1: 253–274. doi:10.1023/A:1010039224868.

Rahman, K. M. M., and M. A. Islam. 2014. "Nutrition-sensitive Agriculture in Bangladesh: A Review." *Food Security* 6: 671–683. doi:10.1007/s12571-014-0380-2.

Rahman, M. H. 2001. *The Influence of Extension on the Introduction of Organic Farming in Bangladesh*. Litverlag Münster-Hamburg-London, Hamburg, Germany.

Ramesh P, Panwar NR, Singh AB, Ramana S, Yadav SK, Shrivastava R, Rao AS. 2010. "Status of Organic Farming in India." *Current Science* 98:1190–1194.

Ramesh, P., M. Singh, and A. S. Rao. 2005. "Organic Farming: Its Relevance to the Indian Context." *Current Science* 88: 561–568.

Rasul, G., and G. B. Thapa. 2003. "Sustainability Analysis of Ecological and Conventional Agricultural Systems in Bangladesh." *World Development* 31: 1721–1741. doi:10.1016/S0305-750X(03)00137-2.

Reddy, BS. 2016. "Soil Fertility Management in Semiarid Regions: The Sociocultural, Economic and Livelihood Dimensions of Farmers' Practices–*A Case of Andhra Pradesh*." In N. Ghosh, P. Mukhopadhyay, and A. Shah, Panda M (Eds.): Nature, Economy and Society, , Springer, New Delhi, 195–223.

Reganold, J. P., and A. Dobermann. 2012. "Agriculture: Comparing Apples with Oranges." *Nature* 485: 176–177. doi:10.1038/485176a.

Ribaudo, M. O. 1998. "Lessons Learned about the Performance of USDA Agricultural Non-point Source Pollution Programs." *Journal of Soil and Water Conservation* 53: 4–10.

Rigby, D., and D. Cáceres. 2001. "Organic Farming and the Sustainability of Agricultural Systems." *Agricultural Systems* 68: 21–40. doi:10.1016/S0308-521X(00)00060-3.

Samie A, Abedullah, Ahmed M, Kouser S. 2010. "Economics of Conventional and Partial Organic Farming Systems and Implications for Resource Utilization in Punjab (Pakistan)." *Pakistan Economic and Social Review* 48:245–260.

Sarker, M. A. 2010. "Adoption of Organic Farming and Sustainable Livelihood Improvement of the Smallholders: The Case of Organic Agriculture Extension by Proshika in Bangladesh." Published PhD Thesis. United Graduate School of Agricultural Sciences, Tottori University, Japan.

Sarker, M. A., and Y. Itohara. 2008. "Organic Farming and Poverty Elimination: A Suggested Model for Bangladesh." *Journal of Organic Systems* 3: 68–79.

Sarker, M. A., Y. Itohara, and M. Hoque. 2009. "Determinants of Adoption Decisions: The Case of Organic Farming (OF) in Bangladesh." *Extension Farming Systems Journal* 5: 39–46.

Seufert, V., N. Ramankutty, and J. A. Foley. 2012. "Comparing the Yields of Organic and Conventional Agriculture." *Nature* 485: 229–232. doi:10.1038/nature11069.

Singh, R. B. 2000. "Environmental Consequences of Agricultural Development: A Case Study from the Green Revolution State of Haryana, India." *Agriculture, Ecosystems & Environment* 82: 97–103. doi:10.1016/S0167-8809(00)00219-X.

Singh, S., and R. George. 2012. "Awareness and Beliefs of Farmers in Uttarakhand, India." *Journal of Human Ecology* 37: 139–149. doi:10.1080/09709274.2012.11906458.

Soltani, S., H. Azadi, H. Mahmoudi, and F. Witlox. 2014. "Organic Agriculture in Iran: Farmers' Barriers to and Factors Influencing Adoption." *Renewable Agriculture and Food Systems* 29: 126–134. doi:10.1017/S1742170513000069.

Stepanovic, S., A. Datta, B. Neilson, C. Bruening, C. Shapiro, G. Gogos, and S. Knezevic. 2016. "The Effectiveness of Flame Weeding and Cultivation on Weed Control, Yield and Yield Components of Organic Soybean as Influenced by Manure Application." *Renewable Agriculture and Food Systems* 31: 288–299. doi:10.1017/S1742170515000216.

Sumon, K. A., A. Rico, M. M. S. Ter Horst, P. J. Van den Brink, M. M. Haque, and H. Rashid. 2016. "Risk Assessment of Pesticides Used in Rice-prawn Concurrent Systems in Bangladesh." *Science of the Total Environment* 568: 498–506. doi:10.1016/j.scitotenv.2016.06.014.

Surekha K, Rao KV, Shobha Rani N, Latha PC, Kumar RM. 2013. "Evaluation of Organic and Conventional Rice Production Systems for Their Productivity, Profitability, Grain Quality and Soil Health." *Agrotechnol* S11:006.

TechSci Research. 2017. *Global Organic Food Market Forecast and Opportunities, 2020*. Manhattan, New York, USA.

Timprasert, S., A. Datta, and S. L. Ranamukhaarachchi. 2014. "Factors Determining Adoption of Integrated Pest Management by Vegetable Growers in Nakhon Ratchasima Province, Thailand." *Crop Protection* 62: 32–39. doi:10.1016/j.cropro.2014.04.008.

Tisdell, C., M. Alauddin, M. A. R. Sarker, A. Rashid, and M. A. Kabir. 2019. "Agricultural Diversity and Sustainability: General Features and Bangladeshi Illustrations." *Sustainability* 11 (21): 6004. doi:10.3390/su11216004.

UBINIG. 2003. *Nayakrishi Andolon, a Booklet Published by UBINIG*. Ring Road, Shyamoli, Dhaka-1207, Bangladesh.

Uddin, M. N., S. Ahmed, and G. M. A. Halim 2011. "Status of Organic Farming in Bangladesh." Country paper submitted to regional workshop on "ANSOFT" of AFACI PAN-ASIAN Project, RDA, Suwon, Korea.

Uddin MN, Siddiqy MA, Al-Mamun MH, Islam F, Halim GMA, Bari ML. 2016. "Impact of Organic and Conventional Practices On, Soil Health and Crop Yield under Tropical and Subtropical Environment of Bangladesh." *International Journal of Environmental and Agriculture Research* 2:89–100.

Uddin, M. T., A. R. Dhar, and M. M. Islam. 2016. "Adoption of Conservation Agriculture Practice in Bangladesh: Impact on Crop Profitability and Productivity." *Journal of the Bangladesh Agricultural University* 14: 101–112. doi:10.3329/jbau.v14i1.30604.

UNDP. 2006. *Desertification in Bangladesh. A Publication on World Environment Day 2006*. United Nations Development ProgrammeNew York, USA.

Valkila, J. 2009. "Fair Trade Organic Coffee Production in Nicaragua – Sustainable Development or a Poverty Trap?" *Ecological Economics* 68: 3018–3025. doi:10.1016/j.ecolecon.2009.07.002.

Vogl, C. R., L. Kilcher, and H. Schmidt. 2005. "Are Standards and Regulations of Organic Farming Moving Away from Small Farmers' Knowledge?" *Journal of Sustainable Agriculture* 26: 5–26. doi:10.1300/J064v26n01_03.

Weinberger, K. 2013. "Home and Community Gardens in Southeast Asia: Potential and Opportunities for Contributing to Nutrition-sensitive Food Systems." *Food Security* 5: 847–856. doi:10.1007/s12571-013-0299-z.

Wijitkosum, S. 2020. "Reducing Vulnerability to Desertification by Using the Spatial Measures in a Degraded Area in Thailand." *Land* 9: 49. doi:10.3390/land9020049.

Willer, H., and J. Lernoud, Eds. 2019. *The World of Organic Agriculture. Statistics and Emerging Trends 2019*. Bonn, Germany: Research Institute of Organic Agriculture (FiBL), Frick, and IFOAM – Organics International.

Yoshino, K. 2010. "Historical Development, Present Situation and Prospects of Organic Farming: Examples from Japan and Bangladesh." In: Proceedings of the International Conference on Asian Rural Sociology IV: The Multidimensionality of Economy, Energy and Environmental Crises and their Implications for Rural Livelihoods (L. L. Tolentino, L. D. Landicho, S. Wun'Gaeo et al. Eds.), 7–10 September, Legazpi City, Philippines, pp. 263–276.

Zulfiqar, F., and G. B. Thapa. 2016. "Is "Better Cotton" Better than Conventional Cotton in Terms of Input Use Efficiency and Financial Performance?" *Land Use Policy* 52: 136–143. doi:10.1016/j.landusepol.2015.12.013.

Zulfiqar, F., and G. B. Thapa. 2018. "Determinants and Intensity of Adoption of "Better Cotton" as an Innovative Cleaner Production Alternative." *Journal of Cleaner Production* 172: 3468–3478. doi:10.1016/j.jclepro.2017.09.024.

Zulfiqar, F., R. Ullah, M. Abid, and A. Hussain. 2016. "Cotton Production under Risk: A Simultaneous Adoption of Risk Coping Tools." *Natural Hazards* 84: 959–974. doi:10.1007/s11069-016-2468-9.