Chantel Hoeve
Ir. Lely Lyceum
Amsterdam, North-Holland, Netherlands
Bangladesh, Sustainable Agriculture

Bangladesh: An approach to the challenges brought by soil salinization

Introduction

What would you do if your once green and luscious farmland became a barren desert of salt? How would you earn money if none of the seeds you sow seem to germinate anymore? Due to climate change and ill-suited agricultural practices, farming grounds all over the world are becoming increasingly more saline due to a build-up of salts in the soil, known as salinization (Saline Agriculture Worldwide, 2011). A threat to the livelihood of farmers in the West, but even a bigger problem for farmers in developing nations. One of those nations is Bangladesh. Like the rest of the world, this small nation faces the challenge of producing enough food to supply its exponentially growing population. Farmers experience enormous crop losses because of salinization, and experts predict the situation will worsen in the future (RECARE, 2020). However, such a grim future does not need to become reality. Farmland depreciated due to salinization can be made productive again by growing crops with increased salt-resistance and by introducing and maintaining better agricultural practices. Despite the sizeable challenges salinization brings to the table, it also brings opportunities.

Country and Family

Located in South Asia, neighbored by India and Myanmar, Bangladesh holds a population of roughly 165 million people and a predicted population of 240 million by 2050. It is currently one of the densest populated nations in the world (Worldometers, 2020). As of now, 60,6% of the population lives in rural areas. Bangladesh is a parliamentary representative democratic republic. The economy of Bangladesh has been steadily growing since the sixties and is expected to rise further in the future (Worldometers, 2020). Bangladesh's GDP in 2018 was 274 billion USD (Worldbank, 2020); 19,6% of this total was in the agricultural sector which employs 63% of the population (Nations Encyclopedia, 2020).

Bangladesh has a total land area of 130,170 km^2 and is characterized by two distinctive features: a broad deltaic plain subject to frequent flooding and a small hilly region crossed by swiftly flowing rivers (Brittanica, 2020). The country has a tropical monsoon climate typified by high humidity, high temperatures and heavy seasonal rainfall. Natural disasters such as cyclones and floods accompanied by storm surges recurrently affect Bangladesh. There are three distinct seasons in Bangladesh: a hot, humid summer from March to June, a cool and rainy monsoon season from June to October, and a cool, dry winter from October to March. In general, maximum summer temperatures range between 30°C and 40°C. April is the warmest month in most parts of the country. January is the coldest month when the average temperature for most of the country is about 10°C (WeatherOnline, 2020).

Bangladesh has many major and minor rivers. A large river may be, along its length, joined by smaller rivers called ‘tributaries’. A river and its tributaries form a 'river system'. The rivers systems of Bangladesh have not only shaped the physiography of the land, but also the people’s way of living; the large rivers serve as the main source of water for cultivation and as the principal arteries of commercial transportation. Rivers also provide fish, an important source of protein (U.S. Library of Congress, 2020).

The deltaic plain is composed of fertile soil which has traditionally been used for farming different kinds of crops. In 2016, 70,6% of the land was being cultivated. Rice and wheat are the major agricultural products, but jute and tea, both of which are key sources of foreign exchange, are also of notable importance (Nations Encyclopedia, 2020).

The importation of goods typically exceeds exportation. Imports come principally from China and fellow South Asian countries, while Bangladesh exports goods primarily to Europe, the United States, and Canada. However, farmers cannot afford expensive foreign products. They mostly rely on their food on their self-cultivated crops (Brittanica, 2020). The typical family diet consists of rice, some vegetables, a small amount of pulses and modest portions of fish (FAO, sd).

Farmers in Bangladesh are mostly smallholder farmers. The children of farmers help their parents in the fields and will, in many cases, inherit and take over the farm once they become old enough. Presently many farmers lack a solid understanding of modern agricultural practices and are accordingly assisted by NGOs and government aid (FAO, sd).

Challenge and Impact

Salinization in Bangladesh has both natural and anthropogenic causes. Due to the monsoon climate and the deltaic plain in the south of the country, floods and cyclones regularly submerge farmland. The water eventually evaporates, but the salts are left behind, accumulating in the topsoil of the fields. This is not out of the ordinary; the process is a natural occurrence in this area and it has been for thousands of years (Banglapedia, 2016).

However, researchers concluded that both fluvial floods and tidal floods in Bangladesh are influenced by sea-level rise and increased upstream river flows. Flooding associated with cyclone landfall and resulting storm surges is also projected to increase in extent, up to quadrupling by the end of the century in extreme cases (Haque, 2018). The rising sea-level is instigated by human emission of greenhouse gases into the atmosphere and climate change. Sea-level rise is therefore an indirect cause of salinization (Nunez, 2019).

The economic impact of climate change and salinization is enormous. It is estimated that climate change will decrease agricultural GDP by 3.1% each year, equal to a cumulative loss in added value of 36 billion USD between 2005 and 2050 (Ministry of Foreign Affairs of the Netherlands, 2018). Moreover, Bangladeshi households affected by salinity earn about 20% less a year than those with healthy soils (Chen & Mueller, 2018).

A clear anthropogenic cause is the construction of water retention infrastructure in India and China. For example, the Indian Rivers Inter-link Project consists of a series of dams built along the Ganges and Brahmaputra rivers in India. This project reduces the quantity of water entering Bangladesh, which results in a significant flow decrease. Bangladesh is relatively flat, which means this reduced river flow does not have enough force to push its water through the sea. This way, seawater enters the river, depositing salt into the farmlands (de la Houssaye, 2019).
Incorrect agricultural practices such as improper irrigation are also a big contributor to soil salinization. Crops need fresh water to grow, however even fresh water contains dissolved mineral salts that stay on the land when the water evaporates. The practice of wet rice cultivation demands large amounts of water, unintentionally increasing the salinity of farmland in the process (Banglapedia, 2015).

There is one more human cause seriously exacerbating Bangladesh's salinization problem: shrimp farming. While it is economically viable, the process is damaging to surrounding soil. Saltwater needs to be held stagnant for up to 9 months, inadvertently salinating land used for coastal wet rice production. Resultantly, yields of rice have been diminishing as the state of the soil only continues to worsen. This coastal farmland has effectively been sacrificed for the sake of the shrimp cultivation of other farmers who lost their land's fertility to salinization, perpetuating a negative feedback loop of soil destruction (Banglapedia, 2015).

Due to these causes, salinity is increasing and has increased to a great extent in some areas of Bangladesh. Most crops cannot tolerate this level of salinity. As a result, crop yield, crop diversity and environmental diversity have reduced significantly (de la Houssaye, 2019).

Solutions and Recommendations

It was estimated by the World Bank in 2010 (World Bank Group, 2010) that Bangladesh will need to invest 40 billion USD from 2015 to 2030 in order to implement identified adaptation measures, such as stress-tolerant variety improvement and cultivation, hazard management, surge protection and flood-proofing.

However, the current rate of government spending on climate change adaptation is far less than what is needed: about 1 billion USD per year – 6-7% of the total annual budget (UNEP, 2014). Although this amount is already quite significant, it will need to be multiplied five or six times to cover the assessed costs for climate change adaptation until 2050.

Despite this, Bangladesh has been successful in mobilizing multilateral funding for climate change adaptation when compared to other low-income countries (Nakhooda, et al., 2013). There are currently various ongoing projects to mitigate and adapt to the effects of salinization. Some of these are implemented by multilateral organizations or donor governments, others are NGO projects (Ministry of Foreign Affairs of the Netherlands, 2018).

For Bangladesh to be able to ensure security in food and nutrition, adaptation to the saline soil is direly needed and saline agriculture should be promoted. With saline agriculture, food is produced on salt-affected soils and salt or brackish water is used for irrigation. It is very well possible to grow crops

on salt-affected land, as long as the right salt-tolerant crops are being used, combined with alternative, more situational techniques in irrigation, fertilization and water management. Saline agriculture limits the damage caused by salinization by employing sustainable practices for agriculture and water management, and by making use of salt-tolerant crop varieties (Salt Farm Foundation, 2018). In the short term, saline agriculture could enhance identity, tourism and employment. In the long term, opportunities like saline agriculture could secure or increase the self-sufficiency of countries facing salinization (Bergkamp, Berndsen, Meulenberg, & Prins, 2018). To realize successful saline agriculture that can keep up with the demand for food of the growing population, more funding is required, despite Bangladesh already spending about 1 billion USD annually (UNEP, 2014).

The Bangladesh Rice Research Institute (BRRI) has been contributing to agricultural development in Bangladesh since 1970. The BRRI works towards innovating modern rice varieties and their production technologies through research (Agrow Award, 2017). Traditional rice varieties have adapted to grow in their locality over eons. They provide an evolving pool of traits to be utilized such as salinity tolerance. These landraces have, however, only adapted that particular trait and therefore have a low yield. Conversely, high-yielding commercial varieties have characteristics to produce a high yield of grains but are much more vulnerable to any type of stress. Introducing salinity tolerance into commercial rice is therefore a feasible way to create high-yielding salt-tolerant plants (TEDx Talks, 2018).

For most of its existence, the BRRI has bred traditionally by crossing those two varieties, which has given some successes, but this conventional method is too slow as it takes nearly 10 years to fully develop a new crossed variety (de la Houssaye, 2019). However, precision breeding, which uses DNA markers to ensure transfer of correct loci speeds up this process of creating stress resistant crop varieties. With molecular tools, the regions in the traditional variety responsible for their salt-tolerant trait can be identified (TEDx Talks, 2018).

Apart from precision breeding, which uses the genes of crops of the same species, transgenic breeding is another way of ensuring that desired traits are introduced in crops. Through transgenic breeding, plants that are genetically too distantly related to be crossed traditionally can still receive the desired salt-tolerant genes. For example, the grass species *Porteresia coarctata*, locally called Uridhan, and rice plants cannot naturally cross, since they are genetically too dissimilar. Uridhan is salt-tolerant and has transport proteins that can take the salt out of the cell through salt glands for salt excretion. Transferring these genes to commercial rice varieties by transgenic breeding would greatly increase salt tolerance. Transgenic breeding is, however, under great scrutiny as the effects on biodiversity are unknown. Despite this, the results are promising; a variety of rice introduced to mangrove genes can tolerate growing in water with 1/6th the salinity of seawater (TEDx Talks, 2018).

To ensure that Bangladesh' agriculture can adapt to climate change and increasing soil salinization, money is needed. The government should dedicate a greater percentage of its GDP to this cause to mobilize greater funds. Extra funding for saline farming should come from food companies - such as Unilever and Nestlé - they should see the potential for profit created by a better understanding of plant physiology and salt-tolerance. Subsequently, estimates of the economic and commercial opportunities offered by improving crop production on saline soil are needed. This is necessary to get food companies ready to invest in research. At food and agricultural conferences, food companies can then

be properly reminded of the great economic benefits that can be gained from research into salt tolerance in plants.

Next, the funds from food companies and the government should be distributed among university faculties best equipped for such research. The results of these studies will find their way into agricultural practice, as far as is applicable and commercially attractive. Both universities and food companies in cooperation with NGOs should understand and invest in the need and opportunities. NGOs and the Bangladeshi government are additionally needed to ensure that these changes are achieved in a fair, sustainable and healthy way; new laws may be needed.

The organizations BRAC and CARE, among others, seem to be up to the task. These NGOs are already promoting fair and sustainable agriculture in developing countries.

Building Resources Across Communities (BRAC) has set up early warning system projects in vulnerable areas in southern Bangladesh. With these projects, they identify and map the early signs of land degradation, such as soil salinity and erosion (Ministry of Foreign Affairs of the Netherlands, 2018). The organization also engages in building systems of production and distribution, offering quality seeds at fair prices and developing better crop varieties and practices. As of now, the organization states to have helped 444,000 people access agricultural services in Bangladesh (BRAC, 2020).

The Cooperative for Assistance and Relief Everywhere (CARE) has initiated various projects to help the Bangladeshi people cope with the effects of salinization. From 2013 to 2017 they successfully strengthened existing agricultural extension systems in Bangladesh to sustainably improve food security for over 200,000 people affected by soil salinization (Ministry of Foreign Affairs of the Netherlands, 2018)

Conclusion

Bangladesh is a developing nation heavily affected by soil salinization. Both anthropogenic and natural causes are at the root of the issue. The country's global position and climate combined with the construction of water retention infrastructure, improper irrigation and shrimp cultivation exacerbate this process. It was estimated by the World Bank in 2010 that Bangladesh will need to invest 40 billion USD to implement identified adaptation measures. For Bangladesh to be able to ensure food and nutrition security, adaptation to the saline soil is needed and saline agriculture should be promoted. With the use of modern technologies such as precision breeding and transgenic breeding, salt-tolerant crops can be created. By convincing food companies and the government to invest more in research, and by involving NGOs, feeding Bangladesh in a fair, sustainable and healthy way is entirely attainable in the future.

References

Agrow Award (Director). (2017). *Bangladesh Rice Research Institute | Best Agricultural Organization in Research & Innovation 2017* [Motion Picture].

Banglapedia. (2015, February 8). *Environment*. Retrieved from Banglapedia: http://en.banglapedia.org/index.php?title=Environment

Banglapedia. (2016, March 23). *Agriculture*. Retrieved from Banglapedia: http://en.banglapedia.org/index.php?title=Agriculture#Environmental_issues_related_to_agriculture

Bergkamp, J., Berndsen, A., Meulenberg, V., & Prins, K. (2018). *The socio-economic and ecological potential.* Wageningen.

BRAC. (2020, July 15). *Agriculture and Food Security*. Retrieved from BRAC: http://www.brac.net/program/agriculture-food-security/

Brittanica. (2020, June 30). *Bangladesh*. Retrieved from Brittanica: https://www.britannica.com/place/Bangladesh

Chen, J., & Mueller, V. (2018). Coastal climate change, soil salinity and human migration in Bangladesh. *Nature Climate Change*, 981–985.

de la Houssaye, F. (Director). (2019). *Climate Change, Salinization and Agriculture in Bangladesh* [Motion Picture].

FAO. (n.d.). *Introduction*. Retrieved from FAO: http://www.fao.org/3/ag126e/AG126E05.htm

Haque, A. &. (2018). Present and Future Fluvial, Tidal and Storm Surge Flooding in Coastal Bangladesh. In A. &. Haque, *Ecosystem Services for Well-Being in Deltas: Integrated Assessment for Policy Analysis* (pp. 293-314).

Ministry of Foreign Affairs of the Netherlands. (2018). *Climate Change Profile Bangladesh.* The Hague: Ministry of Foreign Affairs of the Netherlands.

Nakhooda, S., Fransen, T., Kuramochi, T., Caravani, A., Prizzon, A., & Shimizu, N. (2013). *Mobilising International Climate Finance: Lessons from the Fast-Start Finance Period.*

Nations Encyclopedia. (2020, June 30). *Bangladesh - Agriculture*. Retrieved from Nations Encyclopedia:

https://www.nationsencyclopedia.com/economies/Asia-and-the-Pacific/Bangladesh-AGRICULTURE.html

Nunez, C. (2019, February 19). *Sea level rise, explained*. Retrieved from National Geographic: https://www.nationalgeographic.com/environment/global-warming/sea-level-rise/

RECARE. (2020, July 13). *Salinization*. Retrieved from RECARE: https://recare-project.eu/project-information/soil-threats/salinization

Saline Agriculture Worldwide. (2011). *Salinization*. Retrieved from Saline Agriculture Worldwide: https://www.salineagricultureworldwide.com/salinization

Salt Farm Foundation. (2018). *The four pillars of Saline Agriculture.* Salt Farm Foundation.

TEDx Talks (Director). (2018). *How to save crops from sea-level-rise and salinity | Zeba Islam Seraj | TEDxDhaka* [Motion Picture].

U.S. Library of Congress. (2020, June 30). *River Systems*. Retrieved from Countrystudies: http://countrystudies.us/bangladesh/25.htm

UNEP. (2014, May 23). *Bangladesh Uncovers the Crippling Cost of Climate Change Adaptation*. Retrieved from UNenvironment: https://www.unenvironment.org/news-and-stories/press-release/bangladesh-uncovers-crippling-cost-climate-change-adaptation

WeatherOnline. (2020). *Bangladesh*. Retrieved from WeatherOnline: https://www.weatheronline.co.uk/reports/climate/Bangladesh.htm

World Bank Group. (2010). *Bangladesh - Economic of adaptation to climate change : Main report (English).* Washington, D.C.

Worldbank. (2020, June 30). *GDP (current US$) - Bangladesh*. Retrieved from Worldbank: https://data.worldbank.org/indicator/NY.GDP.MKTP.CD?locations=BD

Worldometers. (2020, June 30). *Bangladesh Population*. Retrieved from Worldometers: https://www.worldometers.info/world-population/bangladesh-population/