

Supplementary data S3 – Screenshots of narratives

BIODIGESTERS

Turning waste into electricity

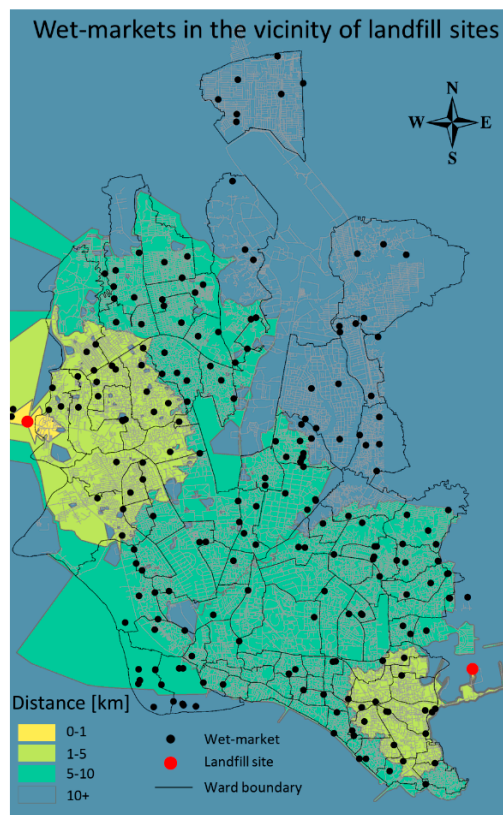
All 21 million inhabitants of Dhaka produce a huge amount of waste every day. The wet markets alone produce 13.5 tonnes of waste daily, of which 11.5 tonnes is organic waste. Uncollected or improperly disposed waste causes significant health, social and environmental impacts on the population. These impacts include odour, traffic congestion, the spread of disease-carrying rodents, air and water pollution and an increased risk of fire. Yet there are only two official landfills serving the city: Amin Bazar (DNCC) and Matuail (DSCC). Although more land has been acquired to expand these existing landfills, they are expected to reach capacity within a few years due to increasing waste production and efforts to make waste collection more efficient. Waste disposal continues to grow and take up space in an ever-growing city. How can this problem be turned into an opportunity? How can waste be used as a potential?

There are many ways to treat waste, and anaerobic digestion is one of them. This biological process yields biogas, a mixture of methane and carbon dioxide, which can be used as a fuel for the generation of electricity. With 500 tonnes of organic waste in a biodigester you can generate just over 1000 kWh of electricity. 500 tonnes is what 37 markets produce together on a daily basis. Assuming that the wet-markets take their waste to the nearest landfill sites, then the waste from 104 markets ends up at the Amin Bazar landfill site and from 70 markets at the Matuail landfill site. This amounts to an average of 1400 tonnes of organic waste for Amin Bazar and 950 tonnes of organic waste for Matuail. A 200-tonne biodigester is planned at Matuail. This capacity can be amply served by market waste alone.

As land in the Dhaka Metropolitan Area is scarce, it is difficult to find space for a biodigester on or near to a secondary transfer station. The existing waste management setup of Dhaka City necessitates identification and implementation of alternate solutions to landfilling that are less costly and more sustainable in the long term. Decentralised processing of biodegradable waste of fresh markets by anaerobic digestion is economically interesting, as transport and landfill operation costs are strongly reduced. Moreover, it reduces greenhouse gas emissions.

Sources

- Voogt, J., Groenestijn, J., Schultze-Jena, A., Mohammed, S., Taylor, J., 2021. *Feasibility Study on Anaerobic Digestion of Waste from Dhaka's Fresh Markets* <https://doi.org/10.5071/29thEUBCE2021-5BV.5.15>

**Facts**

- 85% van fresh market waste is biodegradable matter.
- A medium sized fresh market provides 13.5 tonnes waste per day.
- There are 2 landfill sites in Dhaka with a total area of 94 hectare.



URBAN GARDENING

Potential for rooftop gardening

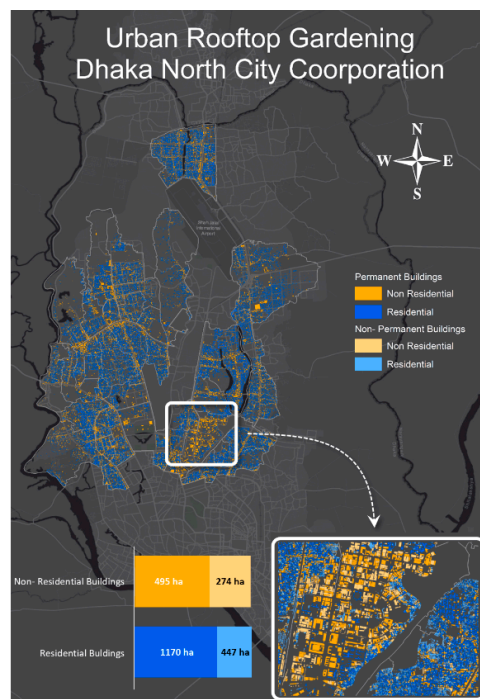
Dhaka's rapid urbanization and growth into surrounding agricultural regions is placing massive demand on urban food supply systems. Moreover, as many cities in the world, Dhaka is facing a rapid decrease in green space and increase in heat island effects. These challenges can be combatted if we look upwards. Rooftop gardening is promoted as a potential solution to these challenges (Smit, Nasr & Ratta, 2001): it improves food security and nutrition, it increases the fruit and vegetable intake, it absorbs carbon emissions and noise, and rooftop gardens are insulators that cool down buildings by absorbing heat and reduce the need for air-conditioning. Moreover, schools with rooftop gardens can encourage children to become interested in gardening and a place to learn about plants, agriculture, and nutrition. Thus there are great many benefits from rooftop gardening. How much rooftop area can we bring under cultivation?

Not all Dhaka roofs can support rooftop gardening; constructions may simply not be strong enough (including most buildings in slums). From all permanent buildings that are strong enough, it is probable that buildings that are used for living are easier to use for gardening than offices, factories and shops, since residential buildings are owned and managed by the residents themselves. Dhaka North, a city corporation that promotes rooftop gardening, is predominantly made up of residential buildings, of which 1170 ha could be suitable for rooftop gardening due to their permanent construction. For the residents of these buildings, the government has an incentive in the form of a 10 percent holding tax rebate. In addition, there is 495 ha of roof space available on properties that do not have a primary residential function

Perhaps we are overestimating things here. After all, not all roofs are flat (pitched roofs are unsuitable for rooftop gardening) and roofs are also used for other purposes that take up space. Now-a-days, open spaces and playgrounds for children are very rare in Dhaka city. One of the few options for children to play is at roofs. Moreover, roof tops are used for drying laundry and for sun bathing in winter. If only a quarter of the roof area is used for these purposes, still 416.25 ha would be left for rooftop gardening. That would make up 0.42 % of the demand of fresh vegetables.

Sources

- Safayet, M., Faqru, A., Hasan, M., 2017, *Present practice and future prospect of rooftop farming in Dhaka city: A step towards urban sustainability*, Journal of Urban Management, 6(2), pp. 56-65
- Smit, J., Nasr, J., Ratta, A., 2001, *Urban agriculture: Food, jobs and sustainable cities*, The urban agriculture network Inc, New York



Facts

- In the Dhaka Metropolitan Area, about 60% of the households live in permanent ('pucca') houses.
- Ways of rooftop gardening: traditional gardening with pots, use of vertical constructions on rooftops, hydroponics, and mushroom gardening.
- In Dhaka North, all permanent buildings together provide 1665 ha of roof area.



FOOD PRODUCTION

Climate risks for agriculture

Of all the food consumed in Bangladesh, 85% is grown in Bangladesh. This is mainly rice, which takes up the majority of agricultural land. Moreover, growing onions, other vegetables, lentils and fish also requires a lot of land. Rice is grown in different cropping systems: as a single variety, multiple varieties or in alternating rotation cycles with other crops. In the near future, the climate will change. The weather will be more extreme resulting in droughts and floods. There are different types of floods. Rivers will more frequently overflow their banks as Bangladesh is located in a delta, at the foot of the Himalayas. Sea level rise will enhance the chance of storm water damage and salt water penetrating much further into the land, hampering current crops to grow. Extreme downpours supply a lot of rainwater at once; too much to be absorbed by the soil, resulting in flash floods. Considering the importance of the food production for Bangladesh, how much of the production lands are likely to be affected by climate change? And where are these areas?

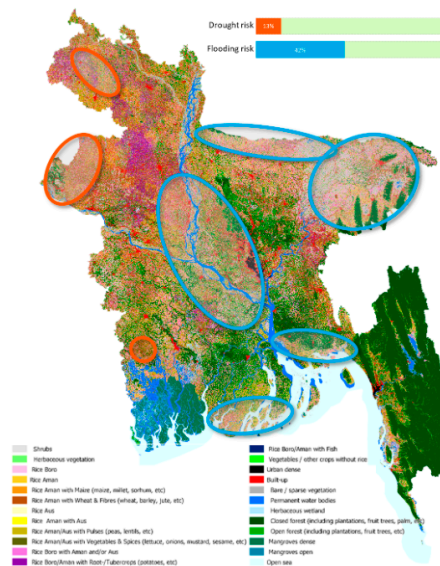
Droughts will occur mainly in the northwest of Bangladesh. Here, primarily rice is grown, partly alternating with other crops. 13% of all cropping areas in Bangladesh are impacted by drought. Floods are likely to occur across many parts of the country. Sea level rise will impact the south, while flash floods will impact the north and east. Lands along the rivers are vulnerable for more severe flooding. In Bangladesh, floods are a necessity, as these provide for fertile soils. As a result, these areas have traditionally been used for agriculture. That is why a large part, 42%, of the area of agricultural land of Bangladesh is threatened by floods.

As large parts of Bangladesh' food barn are likely to be affected by climate change, it is time to think about strategies to cope with the risks. One can think of the introduction of salt- or drought tolerant crop varieties. Another option is to plan for infrastructure in the form of dykes, dams and pumping stations. Moreover, local governments can prepare for periods of reduced yields, by setting up trade relations in the form of open markets.

Sources

- Panteleon, P., van Eupen, M., Verweij, P., 2022, *Risk of climate change for cropping system in Bangladesh*
- van Eupen, M., Verweij, P., Vittek, M., Islam, S., Terwisscha van Scheltinga, C., Hasan, S., 2022, *Cropping systems of Bangladesh - combining and downscaling existing databases* Wageningen Environmental Research report
- SPARSSO, *climate risks*, Bangladeshi Space Research and Remote Sensing Organization
- ILOSTAT, 2021, *Employment in agriculture, Bangladesh*, Worldbank data, <https://data.worldbank.org/indicator/SL.AGR.EMPL.ZS?locations=BD>
- FAOSTAT, 2022, *Land use*, <https://www.fao.org/faostat/en/#data/RL>

Crops at risk from droughts and flooding



Facts

- 85% of all food consumed in Bangladesh is grown in Bangladesh.
- 38% of the population in Bangladesh is employed in agriculture.
- 68% of the area of Bangladesh is used for cropland.



FOOD DESERTS

Urban poor's access to wet-markets

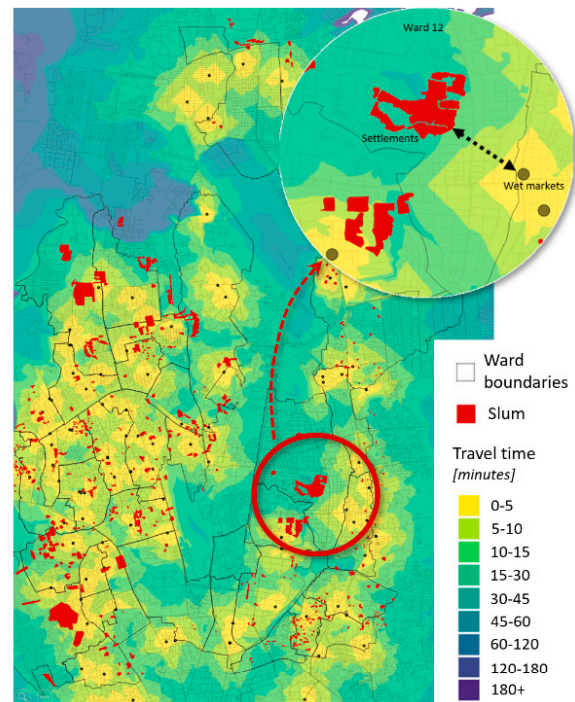
Bustling with sounds and a wide variety of smells, the wet-markets of Dhaka are the most important community places for a wide variety of affordable fresh food items. Wet-markets are the primary and the most popular food distribution points for the majority of Dhaka's residents. For the urban poor, wet-markets are often the only distribution point for accessing fresh food at an affordable price. Though wet-markets are crucial for communities' access to food, the level of access to the wet-markets is not equal for all communities.

The poor do not have the means to preserve food (e.g. a fridge). Thus every day, they must make the trip to an affordable wet-market for a small amount of relatively fresh food. The map shows the walking distance in minutes from the slums to the nearest wet markets. The preferred time for a one-way trip is five to ten minutes. For some areas, the actual required time it takes a person to visit their nearest wet-market can amount to as much as two hours one way.

Communities without any wet-market in their vicinity have two choices—spend additional money for transport to get to the nearest wet-market or depend on the mobile vendors for their food supply. On average, an urban poor family spends around 50% of their monthly income on food. Therefore, it is nearly impossible for them to spend additional money on transportation. The realistic option for the poor is to buy low-quality food from mobile vendors at a higher price.

Sources

- Nadimpalli, M. L., and Pickering, A. J. (2020). A call for global monitoring of WASH in wet markets. *The Lancet Planetary Health*, 4(10), e439-e440
- Unicef



Facts

- Dhaka city has approximately 4 million people living in its 5,000 slums.
- A typical family in a slum consists of 4 people living on an average 6 m².
- Families in urban areas spend 50% of their disposable income on food.



FOOD SAFETY

Foodborne disease risk from fresh markets

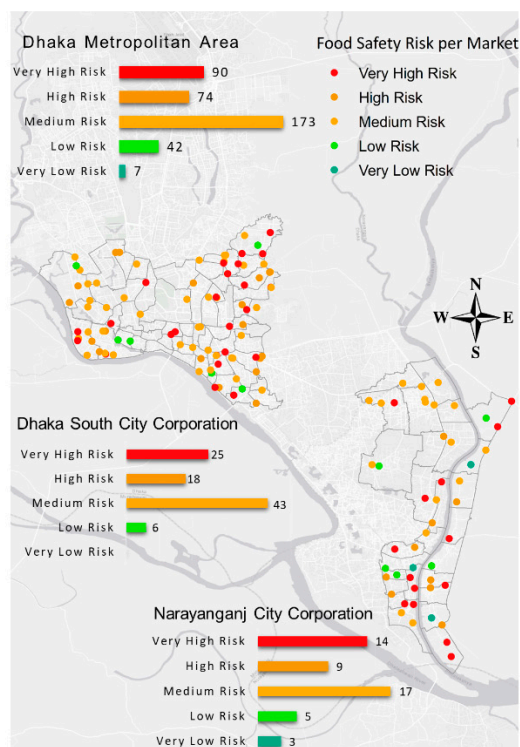
Wet-markets are popular locations for buying affordable food in Dhaka. Widely circulated news of food contamination has made consumers suspicious about the quality of food on wet-markets. The chance of infection by a foodborne disease cannot be neglected. Seven percent of consumers indicate to have suffered from diarrhea as a result of eating contaminated food in the past month. Every year, 30 million people suffer from food poisoning in Bangladesh. What is the source of this contamination and what potential measures can reduce food-borne diseases?

Food safety is compromised by the lack of proper facilities and practices at wet-markets: separation of food items, sanitation, availability of water for rinsing, cleanliness, a designated place for dumping waste and a dedicated facility for slaughtering animals. In a study of 386 markets from across the four city corporations of the Dhaka Metropolitan Area, the availability of these facilities and use of practices was mapped. Only seven markets (equals: two percent) already comply with all these food safety practices. The majority of markets lack one or more of these practices. Most markets do provide for segregation of food products. These markets have special zones where food stalls with certain food items are clustered, although vendors often ignore this. It is not uncommon to find a vegetable seller in between fish or meat vendors, and vice versa. A segregated slaughterhouse facility is lacking at most of the markets. This puts food safety at risk and significantly increases the chance of cross-contamination.

Enforcement of separation of food groups seems an easy solution to lower the chance for cross-contamination. Slaughter house and toilets require extra space and adjustments in constructions, which will not be feasible on every market. The availability of services does not mean much unless they are well maintained and available equally for all the vendors and customers.

Sources

- Snoek, H., Pamuk, H., Raaijmakers, I., Janssen, V., Begum Chowdurry, K., Akter, S., Sijtsema, S., 2021. *Consumers' health and food safety perceptions in the Dhaka metropolitan area* <https://doi.org/10.18174/550216>
- FAO and World Bank, 2021, *An assessment of fresh markets in the Dhaka metropolitan area* Situation report no.14
- Bangladesh Bureau of Statistics, 2021, *Statistical yearbook of Bangladesh* Year book 2020



Facts

- Dhaka has 386 fresh markets.
- 85% of Dhaka's households obtain food from fresh markets.
- Every year, 30 million people suffer from food-borne diseases in Bangladesh.
- Acute Watery Diarrhea is the most common condition for hospitalization in Bangladesh.



GENDER

Women at wet-markets

Bangladesh's gender order is partially responsible for existing gender disparities, in which women have limited mobility, decision-making power and access to income. This leads to women having lifelong poor nutritional status, particularly when combined with multiple pregnancies and strenuous work situations. Women, who are generally in charge of cooking and buying food for their families, are supposed to be the prime customers of the wet-markets. Yet, what is the actual share of women present at wet-markets?

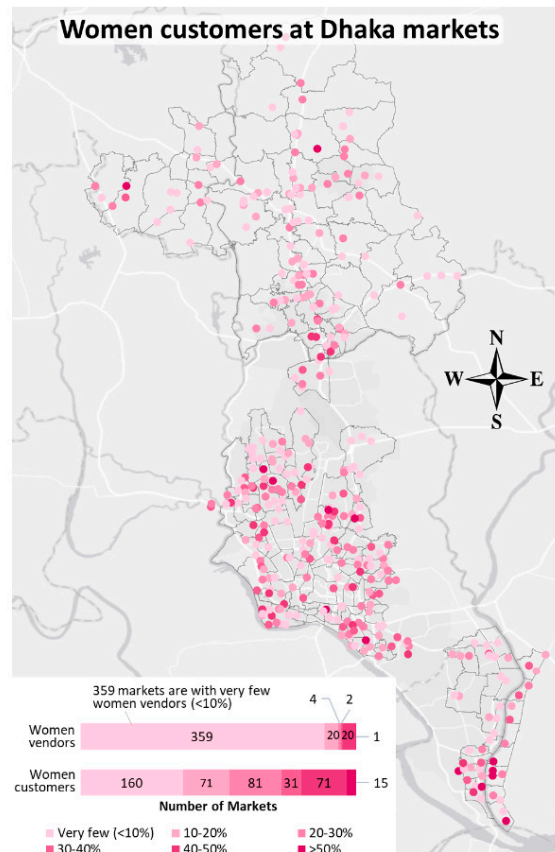
On Dhaka's wet-markets, women can either buy products, or sell them. The share of women customers is relatively low on most of the markets. On only 15 wet-markets in the Dhaka Metropolitan Area, more than half of the customers is women. These are especially concentrated in Dhaka North and Naranjanganlakdgilej. Market vendor is a profession practised mainly by men. On 359 markets the share of women vendors is below 10%. These women vendors mainly sell vegetables.

A growing portion of the market customers are women, as urban life has relaxed traditional gender roles and socio-cultural restrictions on women's mobility. Women in slums especially experience increased mobility and decision-making power.

Sources

- ..., 2022x, *Dhaka Food System: gender analysis and strategy...*

Women customers at Dhaka markets



Facts

- the average percentage of women attending wet-markets themselves is 21%.



WASTE MANAGEMENT

Waste of wet-markets

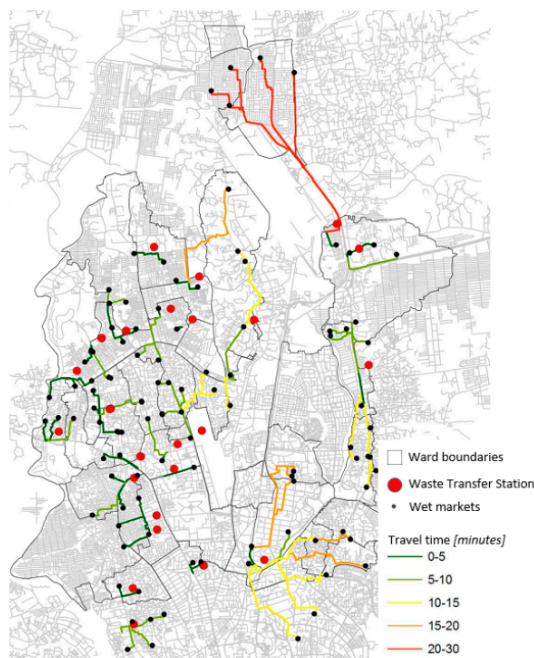
Imagine 47,000 people per square kilometer living side by side. Dhaka, with a staggering 21 million people in total, is the most densely populated city in the world. Its population continues to grow with a rate of 4.2% per year. Waste generation is increasing at similar rates, posing undeniable challenges to the waste management system of Dhaka. Wet-markets are the most important locations for people to access fresh and affordable food. Depending on their size, these markets generate 8 to 50 tons of waste per day. What is happening to this waste?

To reduce roadside waste dumping, Dhaka North City Corporation (DNCC) has established secondary waste transfer stations (STS). These are intermediate collection points of waste before transferring to landfills or waste processing units outside of the city. The map indicates such stations in the form of red dots. Every day, waste is transferred from wet-markets (represented with black dots on the map) to the nearest STS via trucks. Two types of trucks are used for transferring the waste from wet-markets to STSs- DNCC owned trucks with a capacity of 3.7 tons and private company owned trucks with a capacity of 7.8 tons. Considering both truck types, spatial analysis reveals that 391 trips and 31,000 tk (at the fuel cost of 50 tk per km) are required per day to transfer the waste from all the wet-markets in DNCC to their nearest STSs.

Around 90% of the waste generated at the wet-markets is organic. By treating 60% of this waste at the source, the city can save 240 trips and 20,000 tk on fuel cost. GIS can quickly simulate the real-world change brought by the introduction of the waste management system at the site of waste generation. In addition, it helps to identify the wet-markets with low accessibility to STSs, measure the required capacity of STS, and find suitable locations for new STS's. Such insights help to calculate the feasibility of project interventions through the presentation of measurable change.

Sources

- Enayetullah, I., Sinha, A. M. M., and Khan, S. S. A. (2005). *Urban solid waste management scenario of Bangladesh: problems and prospects*. Waste Concern.
- Yasmin, S., and Rahman, M. I. (2017). *A review of solid waste management practice in Dhaka City, Bangladesh*. International Journal of Environmental Protection and Policy, 5(2), 19-25.



Facts

- The total waste collection rate in Dhaka is 37%.
- 76% of Dhaka's waste is generated by the residential sector.
- Wet markets produce between 8 to 50 tonnes of waste per day.

