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PUBLIC

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This study was carried out by Wageningen Food & Biobased Research, funded by Embassy of the Kingdom of the Netherlands in Dhaka and commissioned by Food and Agricultural Organization of the United Nations.

Wageningen Food & Biobased Research
Wageningen, June 2023

Public

Report 2436
DOI: 10.18174/632787

WFBR Project number: 8141917600-3
Version: Final
Reviewer: Floor Boon
Approved by: Jan Jetten
Carried out by: Wageningen Food & Biobased Research
Funded by: FAO Dhaka
This report is: Public

The research that is documented in this report was conducted in an objective way by researchers who act impartial with respect to the client(s) and sponsor(s). This report can be downloaded for free at https://doi.org/10.18174/632787 or at www.wur.eu/wfbr (under publications).

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Contents

Preface

This report is the result of a study caried out as part of the FAO – WUR collaboration project "Support for Modelling, Planning and Improving Dhaka's Food System (DFS)". The project was funded by the Embassy of the Kingdom of the Netherlands (EKN) in Bangladesh and implemented under an Operational Partner Implementation (OPIM) agreement with the Food and Agriculture Organization of the United Nations (FAO) by the Wageningen University and Research (WUR). FAO was the implementing agency responsible for implementation, oversight, monitoring, and guidance. The authors gratefully acknowledge the contribution of Mohammad Mahfuz, Liza Hagidok, Pedro Garzon Delvaux, Xavier Bouan, John Taylor and Seyam Mohammed (FAO Dhaka), Melanie Kok, Bob Castelein, Bas Hetterscheid and Marion Herens (Wageningen University and Research).

Summary

Fresh markets in Dhaka (vegetables, fruits, meat, fish) produce large amounts of waste which are currently transported to landfill sites. However, landfilling requires land area and causes an atmospheric emission of methane, a potent greenhouse gas. Therefore, the policy of the city corporations (Dhaka North City Corporation (DNCC) and Dhaka South City Corporation (DSCC)) is to stop landfilling and process fresh market waste in a different way. As part of the FAO – WUR project "Support for Modelling, Planning and Improving Dhaka's Food System (DFS)" alternatives for valorising fresh market waste were studied: biogas (a renewable fuel) production from the organic fraction and black soldier fly larvae production (a feed for chicken and fish). In this report decentral and central digestion (biogas production) are evaluated.

Decentral digestion (11.5 tonnes organic waste per day) appeared to be more cost effective than the current method (landfilling) in which high costs for transport and landfilling are made. However, the land area requirement for decentral biogas production plants (250 m^2) is the most important drawback. Generally it is not available near current markets.

The alternative is central digestion. That processes the waste from a number of markets (up to 10) on a site outside the residential areas, e.g., on the current landfill sites, benefits from the economy of scale (less costly per tonne waste processed) and better availability of skilled operators and engineers at a large waste processing plant at which more activities take place (e.g., eco-town with composting plant, recycling/sorting facilities, and waste-to-energy plant). Larger plants can hire more operators and engineers which have different specializations and skills.

A design was made for processing 100 tonnes of the organic fraction of fresh market waste per day. It is estimated that this plant produces net 444 kW renewable electricity, which can be supplied to the local electricity grid. The solid fraction of the digestate can be converted into compost. The investment costs for such a central digestion plant, including engineering and installation are estimated at 103 million BDT, an order of magnitude lower than the investment costs previously estimated by DSCC (2019). The revenues from the sales of the electricity almost cover the costs for the transportation of the waste, the interest for the investments, the maintenance, and labour costs. This is a considerable cost saving compared to landfilling. The payback time for the investments is estimated at 3.4 years. If the investments would be 50% higher, the payback time may still be acceptable (6 years). It can be concluded that central digestion has an interesting business case, it saves land area (landfilling) and it prevents emission of large amounts of methane (a potent greenhouse gas) into the atmosphere.

1 Introduction

1.1 Background

The project “Support for Modelling, Planning and Improving Dhaka’s Food System (DFS)” aims to support the Government of Bangladesh at different national levels to develop an appropriate food agenda for the Dhaka Metropolitan Area (DMA) (which is collectively comprised of the Dhaka North City Corporation, Dhaka South City Corporation, Gazipur City Corporation and Narayanganj City Corporation). On one hand it is designed to build capacity and enhance skills that integrate food security, nutrition, and value chains into urban planning, while on the other it explores policy options and interventions that could improve access to, and the distribution of, safe, affordable, and nutritious food within the DMA, reduce urban food waste, and encourage consumers to make more informed food choices. Strong engagement with both the private sector and civil society is pursued by the project as necessary element to support the desired enabling environment and regulatory policy to assist the Government of Bangladesh to achieve its obligations under the Dhaka Food Agenda (https://www.fao.org/bangladesh/news/detail-events/en/c/1504843/).

1.2 Problem statement

The project focusses on reducing food loss and waste. Food waste reduction and valorisation is one of the subjects of the project and one source of attention is the waste generated by fresh markets (also known as wet markets). In such markets, vegetables, fruit, meat, poultry, bread, rice and spices are sold to consumers or to shops (wholesale market). Part of the food is not sold, such as cutting, peels, bones, pieces that have become inedible because of damage or fungal growth and pieces that have not been sold at the end of the day. In addition, the market produces wasted packaging materials such as glass, metal, paper and plastics. Currently the mixed waste is collected from the market in buckets and put in vans. These vans transport the waste to secondary transfer stations from where it is transported by trucks to landfill sites. Informal hand pickers select valuable pieces such as glass bottles and metal from the mixed fresh market waste (at the market, the transfer stations and the landfill sites).

Fresh market waste is not the only waste stream that is sent to the landfill sites. It is estimated that Dhaka has dumped 5 million tonnes of waste on landfill sites in 2022 (FAO-WUR, 2023) and that roughly 35% of the waste originates from fresh markets (FAO-WUR, 2023). The largest landfill site is owned by Dhaka South City Corporation (DSCC), which is the Matuail site, which occupies about 150 acres. Another large landfill site, Amin Bazar, is owned by Dhaka North City Corporation (DNCC). That site occupies 53 acres and is still growing rapidly (FAO-WUR, 2023). Several problems are connected to these landfill sites:

- Occupation of land area (competition for other purposes such as agriculture and housing).
- Emission of methane, a potent greenhouse gas.
- Pollution of the environment (groundwater, surface water and atmosphere) by the landfill leachate and odours.
- Attraction of rats.

The growing demand for land area is the main reason why the city corporations want to change the processing of waste. However, emission of methane has become a new point of concern. Methane is a greenhouse gas, 25 times stronger than carbon dioxide. Recently, satellites were used to detect point source emissions of methane all over the world. Landfill sites appeared to be important sources. In these sites the methane is produced by anaerobic biological degradation of organic matter. In April 2021 GHGSat’s newest satellite, Hugo, recorded large quantities of methane (approximately 4,000 kg per hour) coming from the Matuail landfill (https://www.esa.int). In Figure 1 the detected methane concentrations are shown.

Both DNCC (2019) and DSCC (2019) have formulated plans on a new way to process solid waste. The plans foresee in minimizing landfilling. In cooperation with the Japan International Cooperation Agency (JICA) the concept of eco-towns was created. In these eco-towns various processing technologies will be made available to convert and utilize the municipal waste:

- Incineration and energy production (waste-to-energy)
- Biogas production
- Composting
- Recycling

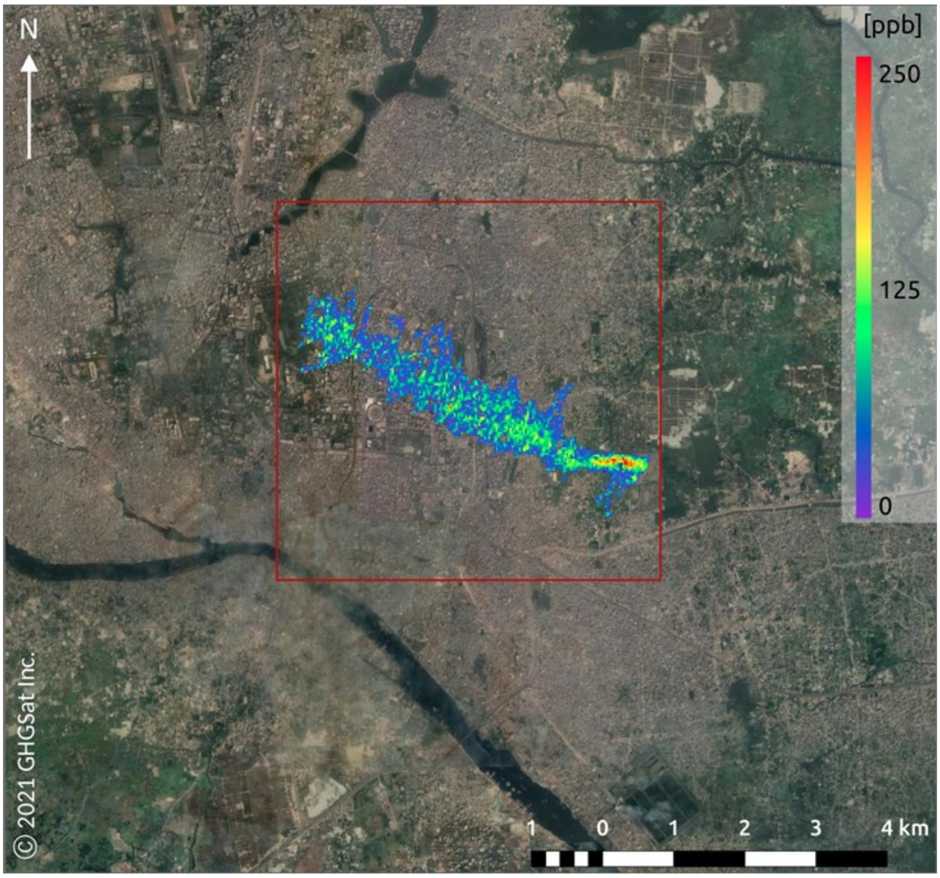

Figure 1 ***Atmospheric methane concentrations near Matuail landfill in Dhaka; emission data shown was captured by GHGSat high-resolution satellite.***

The technology used in the eco-town concept depends on the nature of the waste. Dry organic waste can best be incinerated, wet organic waste (such as fresh market waste) can best be anaerobically digested in biogas production plants (biodigesters), while glass, metal, and plastic can best be recycled. The corporations estimated that 4-6% of all waste, mainly from markets, restaurants, hotels, and offices, will be suitable to produce biogas. Note that this percentage is much lower than the 35% mentioned earlier. One of the reasons for this lower percentage is the plan to compost a large part of the organic waste instead of digesting it. A second reason may be the fact that for digestion waste segregation is required, which is not yet established, while the rate of realization of such segregation is uncertain.

DSCC (2019) describes a plan for processing 3,500 tonnes waste per day. Amongst the various waste processing plants, two biogas plants for 100 tonnes waste per day each have been conceptualized. It is proposed that these should be of the wet digestion type. DSCC (2019) mentions a construction period in 2022-2024 and a start of the bidding process beginning 2022. However, during a biogas seminar in Dhaka in December 2022 it became clear that the bidding process hadn’t started yet (FAO, 2023). DNCC (2019) is planning two biogas plants of 100 tonnes per day each as well.

1.3 Solution explored by FAO and WUR

FAO and WUR have explored how to utilize the fresh market waste as source of energy and nutrients in a biodigester and compost plant or to use it as feed for chicken and fish (e.g., black soldier fly larvae). Both options have been studied the last few years by the project team.

For these routes segregation of fresh market waste is important. Biogas plants cannot handle too much pieces of plastic, paper, metal, glass and stones. They are abrasive and they accumulate in the reactor and digestate and eventually end up in the compost as an undesired contamination. Therefore, a pilot study on market waste segregation is being carried out in ten fresh markets in Dhaka within the DFS project. Bins with different colours are placed in the market; one for organic waste and one for all other waste. Only the organic fraction can be used for anaerobic digestion and biogas production. In another part of the DFS project an inventory of waste streams in fresh markets has been carried out. It appeared that the fresh market waste on average contains 85% organic matter and that the average market produces 18 m^3 waste per day, which is about 13.5 tonnes waste per day of which 11.5 tonnes organic waste (FAO-WUR, 2023).

1.4 Decentral or central production of biogas from fresh market waste?

The project team studied two different strategies to produce biogas from fresh market waste: decentral and central. Decentral digestion can be carried out near a particular market. It involves a small daily input and a relatively small biodigester. As a consequence transport of the waste to a landfill site is not required anymore. The second approach is central digestion in which the market waste from many markets is transported to a site outside the residential areas and in which the biodigester used is large. The team assessed the practical and economic parameters of both approaches. A sensitivity analysis was made to reveal the effect of higher investment costs or higher interest rates on the payback time of the biogas plant.

2 Anaerobic digestion

2.1 General principle of the process

Anaerobic digestion is a biological process carried out by bacteria under conditions without free oxygen. The fresh market waste will be degraded by these bacteria and converted into biogas and a digestate (residue). The biogas can be used to produce electricity in an electricity generator, or it can be purified and supplied to a local gas grid or compressed to produce bottles or tanks with CNG (compressed natural gas) or Bio-LNG (liquified natural gas). Compressed carbon dioxide may be an optional co-product. The digestate can be separated into two fractions: a solid fraction which can be converted into compost and a liquid fraction which can be processed in a larger composting plant or discharged into a sewer or treated and used as irrigation water with nutrients.

Biogas is renewable energy and can be used to replace fossil energy (natural gas, oil, coal). If biogas is converted into electricity, the electricity is renewable energy as well. Therefore, biogas has a value and the production of biogas from waste is a form of valorisation. It depends on the local situation if it is interesting to supply the gas to a gas grid, or put the gas in bottles to be sold elsewhere or to produce electricity. It depends on the availability of gas grids and electricity grids of sufficient capacity near the place of the biogas plant. In addition, it depends on local feed-in tariffs: does the biogas plant owner get a price for gas or electricity supplied to the grid? The market can easily absorb the amounts of renewable energy produced; it is large enough and government policies stimulate the production of renewable energy.

2.2 The unit operations of a biogas plant

The design and design principles have been described as part of the DFS project by Voogt *et al.* (2021) and FAO-WUR (2023).

The most important unit operations are (see Figure 2):

- Shredder to cut the waste in small pieces.
- Macerator pump to further reduce the size of the pieces and mix it with recycled effluent to obtain a slurry which is pumped into the digester.
- Anaerobic digester: a tank reactor that is slowly mixed by the inflow of the macerator pump and an internal mixer. The slurry stays on average 44 days in this reactor. Bacteria degrade (also known as digest) the organic compounds and convert these compounds into a biogas which is composed of roughly 60% methane and 40% carbon dioxide (and small amounts of H_2S, water vapour and other compounds). Because of the high temperatures, there is no need for further heating the waste (bacteria are more active at higher temperatures). The outlet of the digester produces a liquid with suspended solids. These solids are resistant to the digestion process and are pieces of wood, fibres and bones. This mixture is called 'digestate'.
- Screw press (or decanter centrifuge) to separate the digestate into a solid fraction and a liquid fraction.
    - The liquid fraction is discharged into the municipal sewer or used in a more valuable way (depends on the local situation).
    - The solid fraction is transported by a truck to a composting plant. The solid fraction is still too wet (25% dry matter) and cannot be composted alone because it lacks easily degradable compounds that are required to heat up the compost pile. Therefore, it should be mixed with fresh organic material and composted together, usually 50% digestate solid fraction and 50% fresh material. This fresh material can be other organic waste than market waste.
- Storage tank for solid fraction.
- H_2S removal in a bio-scrubber.
- Water removal by cooling.

- Gas holder to store the biogas as a buffer between biogas production and biogas utilization. The alternative is to construct a balloon (using a gastight membrane) on top of the digester.
- Electricity generator to produce electricity. Such generators have an efficiency of 35% which means that 35% of the energy of the biogas is converted into electricity, the other 65% into heat. Therefore, a local application of thermal energy would be welcome.
- Flare in case the biogas production is higher than can be stored and consumed by the generator (in emergency situations).

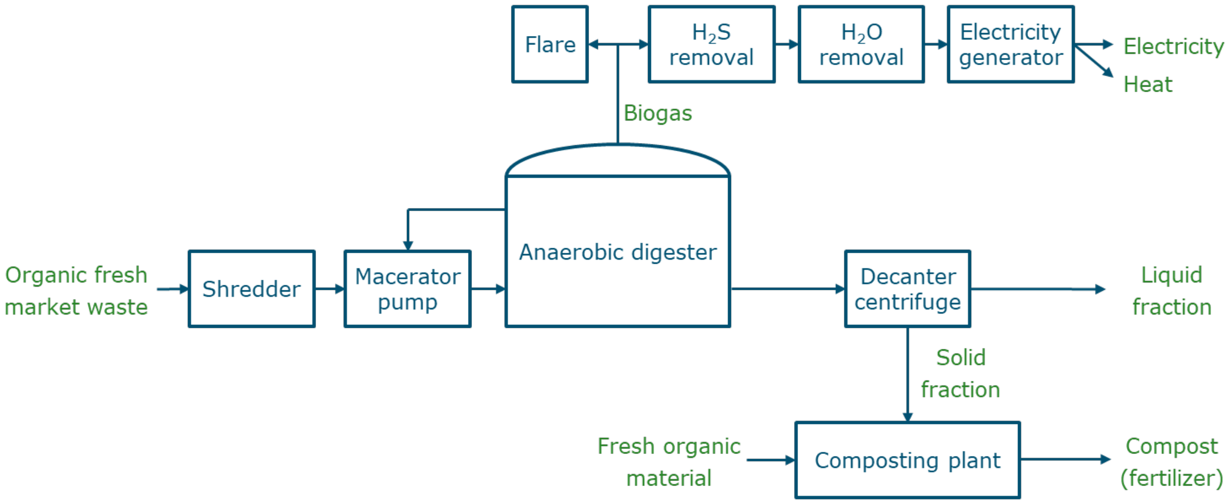

Figure 2 Flow sheet of a decentral biogas plant for fresh market waste.

2.3 Inhibition by citrus fruit peels

A point of attention are the citrus fruit peels. Citrus fruit peels contain limonene, which is an inhibitor of the biological process that produces methane (Wikandri *et al.*, 2015). Calculations, using the data from the paper of Wikandri indicate that if the fresh market waste contains 10% (w/w) citrus peels, failure of the digestion process can occur. However, limonene is biodegraded during anaerobic digestion (Rotaru, 2009), therefore, in a continuously fed and well-mixed digester reactor the concentration of the inhibitory compound will be very low and no problems are expected. Only starting up and shock loads with material containing a lot of citrus fruit peels can cause problems. Pure citrus fruit peels cannot be digested in a batch digestion process because of the inhibition by limonene (personal communication with Wikandri).

3 Decentral digestion of market waste

Our first suggestion was to digest the waste near the market. That would significantly reduce transportation and related costs. Furthermore, a revenue can be obtained from the electricity produced from the biogas.

3.1 Design parameters

In the fresh markets survey (FAO-WUR, 2023), it was estimated that 85% of the waste is organic. Only this fraction can be offered to the digester. The bulk density is estimated at 0.75 tonne/m^3 (Voogt *et al.*, 2021). Since the dry matter content was not measured, it was estimated at 14% based on a Dutch vegetable/fruit waste project (Groenestijn *et al.*, 2017). Other design information is based on Voogt *et al.* (2021):

- Decentral biogas plant for 18 m^3 fresh market waste per day, 11.5 tonnes organic waste per day.
- Residence time in digester is 44 days.
- Expected biogas production is 741 Nm^3 per day.
- The biogas will contain 60% (v/v) methane.
- Energy content biogas is 6 kWh per Nm^3 biogas.
- The electricity generator has an efficiency of 35%.
    - This means that 2.1 kWh can be produced from one Nm^3 biogas.
- The solid fraction of the digestate has a dry matter content of 25%.
- The daily production of the solid fraction of the digestate amounts to 1.3 tonne fresh matter.
- The daily production of the liquid fraction of the digestate amounts to 8.9 m^3.
- The volume of the digester is 561 m^3 including 10% headspace (room to store gas).
- Height of the liquid is 8 m.
- The internal use of electricity is 21% of the electricity produced. Production is 65 kW, therefore 14 kW is consumed in the plant and 51 kW is the net production that can be offered to the electricity grid.

3.2 Estimation of the investment costs

The investment costs for a decentral biogas plant described above were estimated by Voogt *et al.* (2021) to be 28 million BDT (300,000 Euro). These are the fixed capital costs including engineering and installation. It was found that the annual costs (including all costs and revenues) were lower than the costs of the current situation due to the reduced transport (Voogt *et al.*, 2021; FAO-WUR, 2023).

Independent from our study a local supplier of biodigesters made an investment estimation as well for a same waste throughput (tonnes per day), same digester volume, but a few more unit operations (e.g., conveyors, digestate drying beds). The investment estimation was 40 million BDT (personal communication of supplier with the project team). The higher amount may partly be due to the inclusion of more unit operations and partly because the higher estimated dry matter content of the organic fraction of fresh market waste: 25-35% versus 14% in our estimation.

3.3 Required land area

Decentral processing of market waste has the advantage of avoiding transport of waste by trucks to cover the 10-20 km route to the landfill site. The lower transport movements decrease costs and traffic nuisance. Moreover, the nearby processing of the waste and the local utilization of the electricity motivate the local community and workers (to collect and segregate the waste and pay for it): the activities and benefits are more visible. However, it was estimated that the decentral plant described above, which can process the organic waste from an average fresh market, needs 250 m^2 land area. This large land area requirement is the most important drawback of decentral biogas production. Generally, it is not available near current markets.

4 Central digestion of market waste

An alternative to decentral digestion of waste from a single market is central digestion in a large plant that process waste from several markets (up to 10) on a site outside the residential areas, e.g., on the current landfill sites. Benefits are economy of scale (less costly per tonne waste processed) and the better availability of skilled operators and engineers at a large waste processing plant at which more activities take place (e.g., eco-town with composting plant, recycling/sorting facilities, and waste-to-energy plant).

4.1 Design parameters

Our study on decentral digestion was used as a basis to design the large-scale biogas plant. The central biogas plant is a scaled-up version of the decentral plant with some adaptations. The decentral biodigester was designed to process 11.5 tonnes organic waste per day. For the central biodigester we propose to scale up to 100 tonnes fresh organic market waste per day, as this is the capacity which is mentioned in the future vision document of DSCC (Future Vision, DSCC, 2019).

Compared to the decentral digester, the scale-up factor for the central digester is 8.7, which means:

- The digester volume, including head space for biogas storage is 4,880 m^3.
- The liquid height remains 8 m.
- The residence time in the digester remains 44 days.
- The biogas production amounts 6,450 Nm^3 per day (containing 60% methane).
- The net electricity production is 444 kW.
- The production of heat is 1,050 kW.
- The production of liquid fraction of the digestate is 77 m^3 per day.
- The production of solid fraction of the digestate amounts 11.3 tonnes (fresh weight) per day and the solids have a dry matter content of 25%.

Depending on the policy/strategy of the supplier of the digester reactor, the large volume may be split up in two parts, which means two reactors in parallel or in series (each configuration has its own advantages and disadvantages). Whereas in the decentral plant a biogas storage (gasholder) is too dangerous with respect to explosion risk, the central plant may be at an industrial site at which the risks can be minimized. A gasholder can buffer the fluctuating production and consumption of biogas.

In principle, the biogas can be used in various ways. It can be cleaned to produce green gas that can be supplied to a gas grid. In that case the carbon dioxide must be removed from the biogas and the gas has to be pressurized up to the pressure level of the grid. Alternatively, the green gas can be pressurized (to 200 bar), put into bottles and sold as CNG (compressed natural gas). However, for Dhaka the use of biogas to produce electricity seems to be the better option: it is relatively easy and a market for electricity is available nearby the envisaged sites for the biogas plants: the large landfill sites (Future vision, DNCC, 2019; Future Vision, DSCC, 2019). Electricity can be produced from biogas using a combined heat and power unit. Such system converts 35% of the calorific value of biogas into electricity and 65% into heat. The electricity can be supplied to the grid and the heat can be used to dry materials on the site. How the heat can be used depends very much on the other activities on the site. If a composting plant and a waste-to-energy plant are present, all energy and material streams can interact and should be integrated in a masterplan.

In a biogas plant the methane that is produced is not (or considerably less) released into the atmosphere as compared to landfill sites, but it is converted into electricity, water, and carbon dioxide. This way, digestion reduces greenhouse gas emissions. The renewable electricity can replace fossil-based electricity, which again contributes to limiting greenhouse gas emissions.

Twenty one percent of the original dry matter from the market organic waste ends up in the solid fraction of the digestate. These are poorly digestible and non-digestible parts of organic waste such as bones, fibres, shells, phosphate precipitates, sand, clay, seeds, and kernels. In addition, the bacterial sludge that has been produced by the grow of anaerobic bacteria, ends up in the solid fraction as well. The solid fraction contains many nutrients that can be used by crops such as nitrogen, phosphorus, and potassium. Therefore, conversion of these solids into compost is interesting. Composting reduces the weight of the solids (by evaporation of a part of the water and biodegradation) by about 50%, it kills the pathogenic microorganisms and a part of the plant seeds (because of the thermogenic phase of composting; 70°C can be reached), and it stabilizes the solids (no further rotting, low odour). This compost can be used as fertilizer and as material to improve the structure of the soil, e.g., a higher water holding capacity and a higher nutrient adsorption capacity.

However, the digestate solids cannot be composted as such as it lacks energy to reach 70°C. This is caused by the conversion of the readily biodegradable fraction in the biodigester. Therefore, to produce sufficient heat, the digestate solids should be mixed with fresh organic matter (e.g., 50% (w/w) digestate solids and 50% fresh organic matter) and then composted in a composting plant. Composting should start with 40-70% moisture. As digestate solid fraction and market waste are too wet, it should be mixed with drier organic materials e.g., shredded pruning waste. It would be favourable to construct the composting plant nearby the biogas plant.

The liquid fraction of the digestate contains more than 99% water. Furthermore, it contains ammonia, ortho-phosphate, potassium, sulphide, sodium, magnesium, calcium, and many other minerals and soluble organic compounds. In principle it can be used as a fertilizer for crops. Various options exist to process the liquid fraction:

- Partly evaporate the water using use the surplus heat of the generator. Add the concentrate to the composting process.
- Use it as liquid fertilizer via irrigation. In this case the liquid should first be treated e.g., in an activated sludge process to meet the local irrigation water standards. Nearby arable land with crops should be available as well.
- Discharge the liquid in the city sewer. This way the liquid will be treated in the city domestic wastewater treatment plant.

4.2 Economic analysis

The current costs for transport and landfilling for a central digestion plant can be derived using the tariffs given in FAO-WUR (2023):

- 600 BDT per tonne waste for transportation from secondary transfer station to the landfill site.
- 235 BDT per tonne waste for landfilling.

The costs for 100 tonnes per day and 365 days per year are given in Table 1.

Table 1 Current annual costs for transport and landfilling fresh markets waste (excluding collection costs).

Type of cost	BDT
Transport	21,900,000
Landfilling	8,600,000
TOTAL	**30,500,000**

In our earlier study we estimated 28 million BDT investment costs for a biogas plant for 11.5 tonnes waste per day (Voogt *et al.*, 2021; FAO-WUR, 2023). The central plant is 8.7 larger. However, that doesn’t mean that the investment cost are 8.7 times higher as well. Investment costs are not linear with capacity and volume. It is proposed to use a scale-up exponent of 0.6, which means that the investment costs should be multiplied by $8.7^{0.6}$ = 3.66. Our rough estimation of the investment costs of a biogas plant that can process daily 100 tonnes market waste per day amounts to 103 million BDT. This may be slightly higher when a gasholder and conveyors are included. As discussed in paragraph 3.2, a local supplier estimated the investment costs for the decentral biogas plant at 40 million BDT, which is 43% higher than our estimate.

This will be used in a sensitivity analysis. Please note that DSCC estimated the investment cost for a 100 tonnes per day biogas plant at 4,900 million BDT (Future Vison DSCC, 2019), which is an order of magnitude higher.

To estimate the annual costs related to the biogas plant, the same tariffs and calculation rules are used as in FAO-WUR (2023). These are:

- Annual interest on investment costs amounts 5%.
- Annual maintenance costs amount 3% of investment costs.
- Electricity price is 8.16 BDT per kWh.
- One operator costs 120,000 BDT annually.
- The operators work in shifts, a total of 18 operators is required.
- Electricity usage is subtracted from the generated electricity.

The estimated annual costs are shown in Table 2.

Table 2 Current annual costs for transport and digesting fresh markets waste (excluding collection costs).

Type of costs	**BDT**
Transport	21,900,000
Interest investment biogas plant	5,100,000
Maintenance	3,100,000
Labour	2,200,000
Total costs	**32,300,000**
Type of benefit	**BDT**
Electricity (net) 444 x 24 x 365 x 8.16	**31,700,000**

The costs for further processing the digestate solids into compost are not included, nor are the revenues for selling the compost. The treatment of the digestate liquid is not included as well. The annual costs of 32,300,000 BDT minus the benefits from electricity of 31,700,000 BDT results in net annual costs of 600,000 BDT. This is about 30 million BDT lower compared to the current waste transport/landfilling costs. This means that the investment in such a central biogas plant has a payback time of 3.4 years.

The most uncertain factor in our economical assessment is the estimation of the investment costs. Suppose 50% higher investment costs, then the investment costs will be 155 million BDT. The annual costs will rise to 36.5 million BDT, while the revenues still are 31.7 million BDT. As a consequence, the net annual costs are 4.8 million BDT, which is 25.7 million BDT lower than the current waste transport/processing costs. The payback time for the biogas plant increases to 6 years, which may still be acceptable (depends on the policy of the investor). A second uncertainty is the interest rate, now set at 5%. Suppose this will be 10%, then the annual costs will rise to 37.5 million BDT, which is 5.8 million BDT net annual costs and the difference with the current waste transport/processing costs are 24.7 million BDT per year. Then the payback time is 4.2 years.

DSCC has previously estimated that a central digestion plant may cost 4,900 million BDT. That will not lead to a favorable business case. It is probable that because of this high estimation the plans to construct central biogas plants will be canceled. Our estimation of the investment costs is an order of magnitude lower. Based on our estimates, a central digestion plant seems economically feasible.

5 Conclusions

Based on the DFS project aims and interests we explored the feasibility to convert organic food waste from fresh markets into biogas (energy). We studied decentral digestion (producing biogas in digesters very near to the fresh market) and central digestion (producing biogas in digesters on a site outside the residential areas, e.g. on the current landfill sites).

Decentral processing of market waste has the advantage of avoiding transport of waste by trucks to cover the 10-20 km route to the landfill site. The fewer transport movements decrease costs and traffic nuisance. However, it was estimated that the decentral plant, which can process the organic waste from an average fresh market, needs 250 m^2 land area. This large land area requirement is not available near current markets in Dhaka and therefore the most important drawback of decentral biogas production. The alternative is central digestion in large plants that process the waste from several markets. Benefits are economy of scale and the better availability of skilled operators and engineers at a large waste processing plant at which more waste disposal activities take place.

A design of a hypothetical central biogas plant was drafted and evaluated on different aspects. That plant was designed to daily process 100 tonnes organic fraction of fresh market waste. It can is estimated that this plant produces net 444 kW renewable electricity, which can be supplied to the local electricity grid. The solid fraction of the digestate can be converted into compost. The investment costs for such a central digestion plant, including engineering and installation are estimated at 103 million BDT, an order of magnitude lower than the investment costs previously estimated by the DSCC. The revenues from the sales of the electricity almost cover the costs for the transportation of the waste, the interest for the investments, the maintenance, and labour costs. This is a considerable cost saving compared to landfilling. The Dhaka city corporations can benefit from such cost reduction. The payback time for the investments is estimated at 3.4 years. If the investments would be 50% higher, the payback time may still be acceptable (6 years). Central digestion has an interesting business case, it saves land area (landfilling), and it prevents emission of large amounts of methane (a potent greenhouse gas) into the atmosphere.

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To explore the potential of nature to improve the quality of life

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Report 2436

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