Organic flows in Bonaire

Han Soethoudt, Truus de Vrije, Ana Maria López Contreras

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Deliverable reports D1.1 & D1.2 from the project "Sustainable and Circular Organic Waste and Sargassum Management on Bonaire" (Short name: BONCIRC)
"Assessment of the amounts and applications of biomass flows in Bonaire"

Authors: Han Soethoudt, Truus de Vrije, Ana Maria López Contreras

Institute: Wageningen Food & Biobased Research

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PO box 17, 6700 AA Wageningen, The Netherlands, T + 31 (0)317 48 00 84, E info.wfbr@wur.nl, www.wur.eu/wfbr.

With contributions from:
Melinda Marchena (SELIBON), Maurice Adriaens (LVV), Sabine Engel (Mangrove Maniacs), Raymond Silberie (WEB), Rosanne Jansen (WEB)

BonCirc project partners:
All Optimal B.V.
Punta Blanku chicken farm (PBCF)
Servisio di Limpiesa di Boneiru (Selibon N.V.)
Water en Energiebedrijf Bonaire N.V. (WEB)
Together For The Better Good (TBG)
Openbaar Lichaam Bonaire (OLB)
Department of Agriculture, Cattle breeding and Fisheries (LVV)
Agritera

Cover photo: Sargassum influx in Lagoen 2022, by Matthijs van der Geest (WUR)

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Summary

Bonaire is an island in the Leeward Antilles in the Caribbean Sea. Its capital is Kralendijk, near the ocean on the lee side of the island. Aruba, Bonaire and Curaçao form the so called ABC islands, 80 km off the coast of Venezuela. Unlike much of the Caribbean region, the ABC islands lie outside Hurricane Alley. The islands have an arid climate that attracts visitors seeking warm, sunny weather all year round.
This report is written within the project Sustainable and Circular Organic Waste and Sargassum Management on Bonaire (short name: BONCIRC)[1]. This project focuses on the development of approaches to sustainable management of organic waste streams in Bonaire, from a circular perspective. Currently, in the island. organic waste is collected jointly with other types of wastes and mostly landfilled. This causes GHG emissions, nutrient leakage and eutrophication of natural environments and the coastal habitat. The biomass collected from the Sargassum seaweed influxes, that cause severe environmental damage in the coastal ecosystems, is incorporated to the waste streams to be studied, as management or valorisation options for this stream are lacking.
In this report, the organic residues and wastes have been mapped and assessed in terms of amounts over the year, composition and current uses, to serve as a database for the development of new value chains for their circular valorisation, where possible. As part of BONCIRC, a waste analysis of the streams of industries and private costumers has been performed in 2023 by SELIBON and WUR.
Four types of organic waste streams are defined that are collected by SELIBON or should be relatively easy to collect. These are GFT and garden waste, paper and cardboard, wood and pellets, and chicken and goat manure. The annual availability of these organic waste streams ranges from 700 to more than 9000 tons, in total 16.8 kton. Currently most of the food derived organic waste on Bonaire is used as animal feed. Other organic waste is landfilled, buried (chicken manure) or recycled (paper and cardboard).
Another industrial organic waste stream is sewage sludge which is produced at the two waste water treatment plants on Bonaire, the total weight amounts to 192 ton. Sludge is currently disposed of on the central landfill. Also harvested Sargassum biomass is landfilled. The quantity is highly variable over the years. Sargassum influxes occur only during a limited period of the year, from February till July.

[1] https://www.wur.nl/en/project/circular-uses-of-organic-biomass-streams-in-bonaire.htm

Samenvatting

Bonaire is één van de Benedenwindse eilanden in de Caribische zee. De hoofdstad Kralendijk ligt aan kust aan de lijzijde van het eiland. Aruba, Bonaire en Curaçao vormen samen de ABC eilanden gelegen op 80 km van de kust van Venezuela. In tegenstelling tot het grootste deel van het Caribische gebied vallen de ABC eilanden buiten de orkaangordel. Het droge klimaat met warm en zonnig weer gedurende het hele jaar trekt veel bezoekers aan.

Dit rapport is onderdeel van het project "Sustainable and Circular Organic Waste and Sargassum Management on Bonaire" (afkorting: BONCIRC)[1]. Dit project richt zich op de ontwikkeling van processen voor duurzaam management van organische afvalstromen in Bonaire, gezien vanuit een circulair perspectief. Momenteel wordt organisch afval verzameld samen met andere afvalstromen en afgevoerd naar de vuilstort. Dit veroorzaakt emissies van broeikasgassen, lekkage van nutriënten, en eutrofiëring van de natuurlijke omgeving en de kust habitat.

Aan de lijst van afvalstromen is Sargassum zeewier toegevoegd. Sargassum wordt verzameld na strandingen op de kust waar het ernstige schade veroorzaakt aan het lokale ecosysteem. Op dit moment zijn opties voor management en valorisatie van deze biomassa nog niet beschikbaar.

In dit rapport zijn organisch afval en residuen in kaart gebracht en beoordeeld op grond van de hoeveelheid per jaar, de samenstelling en de huidige toepassing. Deze gegevens kunnen dienen als basis voor de ontwikkeling van mogelijke nieuwe waardeketens voor circulaire valorisatie. Als onderdeel van BONCIRC is in 2023 een analysis van de afvalstromen van de industrie en huishoudens uitgevoerd door SELIBON en WUR. Vier type organische afvalstromen die door SELIBON worden verzameld of relatief eenvoudig verzameld zouden kunnen worden zijn gedefinieerd. Dit betreft GFT en tuinafval, papier en karton, hout en pellets, en kippen en geitenmest. De jaarlijkse productie van deze organische stromen varieert van 700 tot meer dan 9.000 ton, in totaal 16,6 kton. Momenteel wordt het merendeel van het voedings-gerelateerde organisch afval gebruikt als diervoeder. Andere organische afvalstromen worden gestort, begraven (kippenmest) of gerecycled (papier en karton).

Een andere industriële organische afvalstroom is rioolwaterslib dat geproduceerd wordt bij de twee afvalwaterzuiveringsinstallaties op Bonaire. De totale jaarlijkse hoeveelheid slib is 192 ton. Dit wordt nu afgevoerd naar de stortplaats.

Ook de geoogste Sargassum biomassa wordt gestort. De hoeveelheid kan van jaar tot jaar sterk wisselen. De beschikbaarheid beperkt zich tot een periode van februari tot juli als de strandingen plaatsvinden.

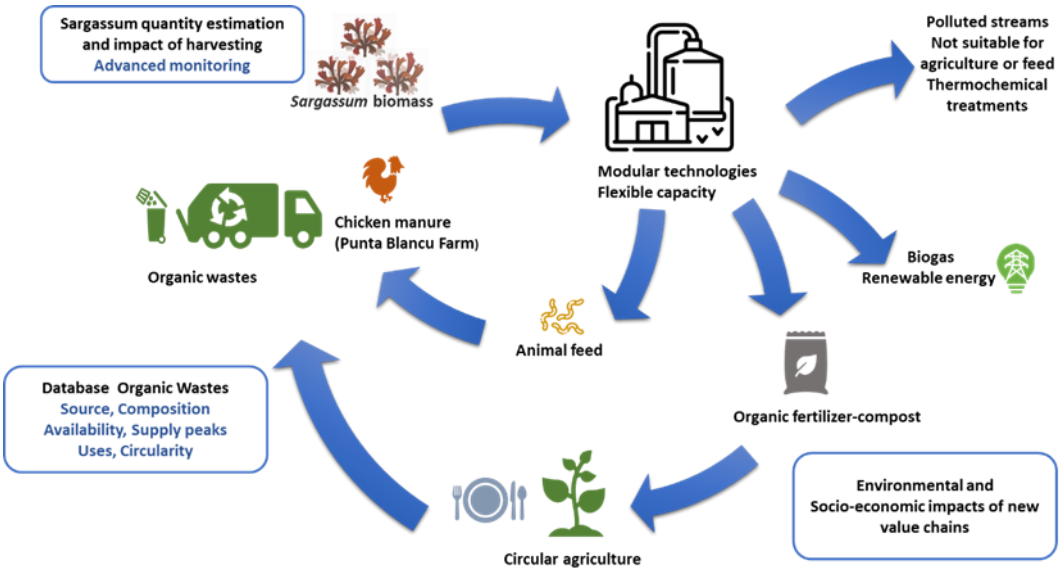
1 Introduction

In the BONCIRC project circular approaches to sustainable management of organic waste streams in the Dutch Caribbean are developed, using Bonaire as a case study. On Bonaire, organic waste is collected jointly with other waste and mostly landfilled. Landfilling causes GHG emissions, nutrient leakage and eutrophication of the natural environment and coastal habitat. The aim of BONCIRC is to develop new value chains for circular valorisation of organic residues and wastes on Bonaire.

This report describes the mapping and assessment in terms of amounts over the year, composition and current uses, of organic waste streams which will serve as a database for further studies (WP 1 "Mapping of organic waste availability and current uses"). The organic waste streams involved are amongst others food and garden waste, paper and wood, manure and sewage sludge. Another relevant waste stream on Bonaire is Sargassum biomass from influxes near the coast and beaches. These influxes have a negative impact on the coastal environment, tourism industry and public health. Currently valorisation options for Sargassum are lacking. The timing, distribution, and scale of Sargassum biomass are studied in WP 2 ("Quantification of pelagic Sargassum biomass, environmental impact and composition in coastal bays of Bonaire") and recently, the results are reported by van der Geest et al. (2024).

The results of the present study in WP 1 will be used to identify organic waste streams that can be used as substrate for animal feed, insect farming (for use as chicken feed), mushroom cultivation, or other uses as composting, fertilizer, or fuel and energy production by thermochemical processes. These options will be assessed in WP 3 "Direct application of streams for high value applications". In WP 4 selected organic waste streams will be assessed for biogas production or other biological conversions ("Application testing of biomasses for biogas, compost and biological conversion").
Based on the input of the previous WPs, processing plant(s) will be designed for clean and/or polluted organic waste streams (WP 5 "Design of an organic streams overall system") and a socio-economic impact assessment is conducted combined with the results on insights from environmental impact (WP 6 "Environmental, economic and social assessments of value chains).

The scheme below shows the concept of circular waste management of organic streams as studied in BONCIRC.



2 General information Bonaire

Bonaire is an island in the Leeward Antilles in the Caribbean Sea. Its capital is Kralendijk, near the ocean on the lee side of the island. Aruba, Bonaire and Curaçao form the so called ABC islands, 80 km off the coast of Venezuela. Unlike much of the Caribbean region, the ABC islands lie outside Hurricane Alley. The islands have an arid climate that attracts visitors seeking warm, sunny weather all year round. Bonaire is a popular snorkelling and scuba diving destination because of its multiple shore diving sites and easy access to the island's fringing reefs.

Early 2020 Bonaire had 20.9 thousand residents, 5.4 thousand more than early 2010 [2]. The island's total land area is 288 square kilometres which is about one and a half times the size of the island of Texel in The Netherlands; it is 38.6 kilometres long from north to south, and ranges from 4.8–8 km wide from east to west. A short 800 metres (0.50 mi) west of Bonaire across the sea is the uninhabited islet Klein Bonaire with a total land area of 6 km^2 (2.3 sq mi). Klein Bonaire has low-growing vegetation including cactus, with sparse palm trees near the water and is bordered by white sandy beaches and a fringing reef. The reefs, beaches and on-island reserves located on both Bonaire and Klein Bonaire are under the protection of the Bonaire National Marine Park, and managed by Stichting Nationale Parken Bonaire (STINAPA)[2]. More information on land use and climate is shown in Annex 4 “Maps of Bonaire” and Annex 5 “Climate of Bonaire”.

Bonaire was part of the Netherlands Antilles until the country's dissolution in 2010, when the island became a special municipality (officially, a "Caribbean public body") within the Kingdom of the Netherlands. It is one of three special municipalities in the Caribbean; the others are Sint Eustatius and Saba. The public entities are autonomous in their own household, but the government can demand co-administration or regulation and administration of the island territories [3]. 80% of Bonaire's population are Dutch nationals, and nearly 60% of its residents were born in the former Netherlands Antilles and Aruba.

[2] https://en.wikipedia.org/wiki/Bonaire, viewed 16-4-2022

3 Economy

To get insight in the economic activities in Bonaire an employment overview is presented in Table 1:

Table 1 Number of people working per SBI-code in 2016 [3].

SBI sectors	% of employees	# people	SBI sectors	% employees	# people
Government, education and care	33.0%	3538	Financial services	2.4%	257
Catering industry	14.5%	1554	Mining	0.6%	64
Construction industry	11.4%	1222	Rental and trade of real estate	0.5%	54
Trade	10.1%	1083	Agriculture, forestry and fishing	0.0%	0
Business services	6.4%	686	Energy supply	0.0%	0
Transport and storage	5.6%	600	Water companies and waste management	0.0%	0
Culture, recreation and other services	5.0%	536	SBI-code unknown	3.2%	343
Industry	4.9%	525	**Total %**	**100%**	
Information and communication	2.5%	268	**Total number of people**		**10720**[3]

Bonaire's economy relies largely on tourism, with about 500 thousand cruise and stay-over tourists per year compared to a population of just over twenty thousand. Direct tourism expenditure is estimated at around 40% of the Gross Domestic Product of 428 million US dollars in 2017. Both direct and indirect tourist expenditure provide jobs for many inhabitants in accommodation and food serving (16%), recreation and cultural activities (9%), construction (7%), wholesale and retail (14%) [4].

3.1 Agriculture

Until 40-50 years ago agriculture and horticulture was a significant sector on the island. Since then, many of the agricultural area is no longer in agricultural use. Reasons for the decline in local production are the increasing prosperity and the possibilities to import at highly competitive prices from countries where production costs are lower. This was accompanied by a diminishing interest of the islanders in their own agriculture and horticulture, which further increased their dependence on imports [5].

The agricultural sector has a modest place in the economy of Bonaire. It is estimated that less than 1% of the economically active population is employed full-time in the agriculture, livestock and fisheries sectors. There are two full-time farmers and an estimated 20 full-time fishermen. Local products, such as watermelon, melon, 'cucumber chikitu' (Antillean cucumber) and beans are available during the rainy season (October to January). The two full-time farmers run a chicken farm (and deliver eggs to all of Bonaire) and a goat farm.[2]

An important role in agriculture was played by the so-called 'kunukus'. More than 100 years ago the idea of renting out large parts of the government domain in small plots and for a small fee to the population for their

[3] Note that numbers don't add up correctly due to rounding errors.

own food supply was hatched. This plan was implemented with the issuance of hundreds of small plots in different areas around Bonaire. Various seasonal crops such as sorghum, beans, pumpkins and melons were grown on these small plots that were called kunukus. The plots were also the place from which small ranchers kept some livestock [1]. Three areas on Bonaire are officially designated agricultural-kunuku:
Rincon and surroundings, Tras Montaña and the area east of Kralendijk known as Bara di Karta [6]. Together these areas cover about 7,000 ha or 25% of the island's surface. Nowadays most kunukus have been abandoned (Fig. 1). Farmers have moved to more urban areas.

Figure 1 Abandoned kunuku [1].

Horticulture
To estimate the size of the cultivated land, data on preparing and ploughing are considered. Preparing kunukus for cultivation happens all year round, and there is a peak in the months of June to September leading up to the rainy season. The peak period for ploughing is from September to November. Irrigated fruits and vegetables can in principle be planted all year round (despite the fact that for some crops, e.g., tomato has a clear seasonality). The ploughed hectares from January to July give an estimate of the horticultural area. The hectares are spread over several kunukus. From 2004 to 2011 between 46 and 209 ha per year have been prepared for cultivation (avg. 108 ha) and between 51 and 126 ha have been ploughed (average 88 ha) [7].

On Bonaire, grain sorghum is the largest crop. In 2014 a field of about 4 hectares sugar sorghum (fodder for goats and sheep) was cultivated [8]. Corn, beans and peanuts need more water and are mainly found in gardens where irrigation is possible. Professional horticulture on Bonaire has received an impulse at the sheltered workshop of the Krusada Foundation, where vegetables are grown in greenhouses as part of the daytime activities. The Krusada's three greenhouses have a total surface area of 500 m^2 [2] (Krusada Green, http://www.fundashonkrusada.org). Various high-yielding crops are grown in the greenhouses, such as spinach, Bok choy and arugula, and various herbs (basil, mint). At the beginning of 2019, the Bon Tera company started with a 0.5 ha greenhouse. Based on experience gained at Krusada, this company grows various types of lettuce, spinach, cucumbers, peppers, yambo, long beans, microgreens and various herbs and sells these products to catering, supermarkets and directly to private individuals.

The largest vegetables production area is at the company Bon Tera. Bon Tera is the first nursery of this size on Bonaire and is located in Kralendijk (Fig. 2). Cherry tomato, snack cucumber, long beans, mint, arugula and lettuce mix were the main crops at the start. Outside the greenhouse mainly cacti and dry shrubs grow in stony soil. In 2019, Bon Tera increased the surface area of the greenhouse by about 45 percent. With the extra space they can grow more and Bonaire is less dependent on the import of vegetables and herbs. The Public Entity Bonaire and the policymakers in The Hague consider this important for the island[4].
In terms of sales, Bon Tera mainly focuses on restaurants and two supermarkets on Bonaire. A lot of spinach goes to the supermarkets, 140 to 160 bags per week. Bon Tera suffers from pest damage (rodents and insects). It is not known how much produce is lost, and how much organic waste is generated, due to these factors.

[4] https://www.nieuweoogst.nl/nieuws/2021/12/15/afzet-groentekweker-op-bonaire-ging-tijdelijk-naar-burgers, viewed 18-4-2022

Figure 2 The Bon Tera greenhouse with shade cloth is 7,250 square meters in size.

There is also hydroponics production of lettuce (Fig. 3). A greenhouse of 10 by 50 m with 32 tables can give an average production of 800 heads of lettuce per week[5]. The weight of one crop is between 170 and 180 grams [9].

Figure 3 Hydroponic lettuce production on Bonaire [9].

Bok choi is a good alternative, it grows into a nice head in 6 weeks. Bok choy has the same life cycle as lettuce. A crop weighs about 200 grams. The market is small due to imports from the US, sales are now a maximum of 100 heads per week. If there would be no import then sales of 300-400 heads per week are possible. Note that hydroponics leads to very small organic waste flows (see youtube video).

Another horticulture producer is Bonaire Daily Fresh[6]. They are using hydroponics as technology for production of vegetables under a controlled environment. The technology used is 100% natural, in organic conditions. The production of vegetables requires less water than traditional agriculture, without using pesticides, herbicides, or chemical fertilizers. Daily Fresh has stopped with the previous aquaponics activities at this location in the premises of LVV [10].

In 2019/2020 it was decided to convert LVV[7] into a knowledge center and to develop the LVV terrain into a business center for agro-entrepreneurs. The idea is to issue plots to private parties and assist them with expertise, information and research. They started recruiting private parties who are using plots on the LVV site for cultivation of fruit and vegetables. In November 2020 LVV issued the first lot, to Bonaire Daily Fresh. The process of finding commercial partners and selling lots takes time, hence LVV started producing again themselves. The crops included okras, aubergines, papayas, small cucumbers, pumpkins, watermelons, warmoes, knuku and watoeoie beans and long beans [11].

[5] https://www.youtube.com/watch?v=WlDn8XFrJD0&ab_channel=POPBonaire, viewed 18-4-2022
[6] https://www.bonairedailyfresh.com/, viewed 15-01-2025
[7] Department Landbouw, Veeteelt en Visserij is part of Openbaar Lichaam Bonaire

LVV is also experimenting with producing hay. Livestock farmers have high input costs because they have to import hay. LVV has ten hectares ready to sow with "mulato" grass, a Colombian kind that should do well on Bonaire. Farmers are encouraged to grow buffalo grass that is suitable for dry periods. LVV provides mowing and baling as a service. There is one challenge though: there is little enthusiasm to work in this sector.

Livestock

There is one professional poultry farm on Bonaire (Punta Blanku Farms N.V.) that produces eggs (using 27,000 hens) and broilers; about 5,000 free range hens and 22,000 in battery cages. On average, every chicken produces one egg per day. Hence 27,000 eggs are produced per day. All 27,000 hens stay for one year and are sold afterwards to farmers or anyone who wants them. There is also an expanding poultry farm in Rincon with over 3,000 hens. This company also produces eggs and meat.

Bonaire has more goats than inhabitants: 32,000 goats against 21,000 people. About 50% live in agricultural areas, 12% in the coastal areas, 37% in the forest and 1% in urban areas. Most of the animals in the coastal zone are probably 'kunuku' swarming animals. If we assume that 80% of these animals are actually kunuku animals (assumption), then there are on Bonaire about 60.6% kunuku goats and about 39.4% animals without owner [1]. So, a large part of the goat population roams freely on the island, feasting on what the fragile nature has to offer. They are also a danger to traffic.

In addition, the (over)grazing leads to erosion, which causes rainwater flowing to the sea to carry soil that can suffocate the coral [12]. Goats are mostly kept non-professionally and often slaughtered for their own use. Goats are milked on one small-scale farm (Aletta's Goat Farm). In some kunukus (rural areas, outside built-up areas) a single cow or pig is also kept. Based on the estimates by the Public Entity Bonaire the number of goat farmers is between 200 and 375 [1].

There is one slaughterhouse on the island, called Amboina, which is government owned. In 2013, there were 2043 goats slaughtered, and in 2014 1944, with a live weight of 18 kg and a carcass weight of 9 kg. The number of goats slaughtered by the slaughterhouse appears to be fairly stable from 2011 onwards. Most likely, a significant proportion of the goats are not slaughtered in the official slaughterhouse.

Recently, the slaughterhouse has been renovated. The slaughterhouse will be equipped for the slaughter of goats, sheep and a pig or cow now and then. The contract was signed on March 1, 2022 and the renovation was finished in 2022.

Table 2 Average number of registered slaughters per year per animal species on Bonaire (average from 2012-2018) [5].

Animal	Bonaire
Cattle	4
Pigs	132
Sheep	295
Goat	1509
Total	**1938**

In Table 3 data are presented for the categories pigs, sheep and goats: the number of animals slaughtered, the total carcass weight of all slaughtered animals and the average carcass weight per animal in a particular year.

Table 3 Number of animals processed and average carcass weight[8] in Amboina slaughterhouse [14].

	pigs			sheep			goats		
Year	Total #	Total (kg)	Kg/animal	Total #	Total (kg)	Kg/anim.	Total #	Total (kg)	Kg/anim.
2004	7	375	53.5	336	4588	13.7	922	10074	10.9
2005	22	851	38.7	333	3845	11.5	1422	15907	11.2
2006	119	4076	34.3	447	5078	11.4	1565	15615	10.0
2007	175	6970	39.8	596	5863	9.8	1579	15939	10.1
2008	175	6464	36.9	209	2448	11.7	1438	14314	10.0
2009	33	1508	45.7	432	4625	10.7	1818	15617	8.6
2010	135	5493	40.7	498	5026	10.1	1643	15939	9.7
2011	218	7716	35.4	617	6286	10.2	2143	22476	10.5
Avg/yr	**111**	**4182**	**37.8**	**434**	**4720**	**10.9**	**1566**	**15735**	**10.0**

Like most small Caribbean islands, Bonaire is largely dependent on imported food. This results in high prices due to import taxes (note that Curacao is another country to Bonaire) and transport costs, and high vulnerability towards price fluctuations and global developments, which both present major risks to food security. While 25% of Bonaire's surface consists of rural areas suitable for on-land food production, current practices of agriculture are small scale, mainly due to small domestic markets and limited access to freshwater (the groundwater is predominantly brackish), electricity, human capacity and know-how, while the widely used practice of extensive husbandry results in suboptimal yield and severe grazing-induced erosion issues [13].

Nevertheless, agriculture, livestock and fisheries have a socio-economic function for many people. Income from agriculture, livestock and fishing supplements the salary or pension. Currently agriculture, animal husbandry and fisheries are practiced extensively. Investments and returns are low.
Local agriculture provides a small part of the market needs in the field of fruits and vegetables. Livestock farming provides eggs and goat and sheep meat. Bonaire is only self-sufficient for eggs. Fishing is mainly seasonal and supplies the local market, but most of the fish is imported. The stray goats, sheep, pigs and donkeys also cause economic damage on Bonaire causing erosion by overgrazing thereby damaging the coral around the island because of the runoff.

Food imports arrives via Curaçao (whereby the food comes mainly from the US and the Netherlands). Since Venezuela proclaimed the ban on export of fruits and vegetables, trade stopped from Venezuela to the Dutch Caribbean islands [2].

Fisheries
Fisheries on Bonaire mainly target large pelagic species. Total landings of the coastal fishery were 103 tonnes in 2014. That year about 30-40 fishermen were active on the island, and the fleet consisted in total of 84 small vessels (<7m) and 26 larger vessels (>7m). Also, shore fisheries using handlines are active on Bonaire. Of the total catch of 103 tonne in 2014, 12 t was caught by shore-based handline fisheries, 30 t by small vessels and 60 t by larger vessels. The value of these fisheries is estimated at 0.7-1 million USD. Fisheries on Bonaire are managed by the fisheries act for the BES islands (Visserijwet BES, 2014) and additional local fisheries regulations for example in the Bonaire National Marine Park (BNMP). Here, fishing activities are restricted (e.g., fish traps are not allowed, several species cannot be landed) and two small No Take Zones have been designated [14].

Main varieties caught are red snapper (23%), fish/piska (species not specified) (14%), tuna (14%), mahi mahi (14%) and barracuda (14%). Other species include lobster, masbangu, amberjack and wahoo [14].

Feed
W&B Advies [15] calculated that the roughage requirement for a herd with 167 goats is about 45 tons DM annually. Feed imports for goats, sheep and chicken in 2010 were 40 tons of concentrate from the

[8] The weight of an animal after slaughter and removal of most internal organs, head, and skin

Netherlands and 650 bags of maize per month from Santo Domingo [1]. But Bonaire wanted to produce animal feed locally. The free range hens require 253 tons of feed, whereas the chickens in battery cages need 768 tons[9] of feed.
Research on Bonaire showed that the grass Brachiaria Mulato II (Fig. 4) gives good production, grows quickly and is easy to hay. It is the most suitable fodder crop for central production with irrigation.
With good fertilization and sufficient water, the grass produces all year round. The production of this roughage is between 25,000 and 35,000 kg DM/year/ha.
Fertilization is crucial for intensive year-round production of grass. There is also animal manure on Bonaire, which is now hardly used. About 1,200 tons of chicken manure is produced per year. Per ha, 10 tons of chicken manure can be applied to the land every year.
The estimates for manure from chicken and goats are based on the following assumptions:

- Chicken: 40 kg/animal/year
- Goat: 200 kg/animal/year

Since there are 30.000 laying hens, the manure production is 1200 tons/year. The estimated number of goats where manure can be collected from is estimated at 10,000, leading to about 2,000 tonnes of goat manure [16].

Other
On Bonaire, cacti are also harvested on a small scale for distilling liqueurs. Because of the tourism on the islands, cultivation of these "specialty" crops would probably have a large potential. This potential is currently not realized (https://www.cadushy.com/).

Middlemen
About half of the seafood sold by middlemen on Bonaire is sold to restaurants, and about half is sold to local/walk-in consumers.

Figure 4 Mulato II in the trial field on the LVV site.

Wholesaler/supermarket
The largest wholesale company of Bonaire is Bonaire Food Group (BFG). BFG owns multiple large supermarkets and supplies fresh products, including seafood to Bonaire and also on Aruba and Curaçao. No interview was conducted with this company. However, through email contact with WWF-NL, BFG explained that they do not source any local seafood. This is due to the restricted supply and availability. In addition, local seafood does not meet the hygiene standards set by BFG [14].

Seafood is being imported to the island in two ways. The main channel being wholesalers, supermarkets and restaurants importing seafood. This import consists of species that are not locally available such as salmon, shrimp and scallop. Local species of which the demand cannot be met, are not available year-round due to seasonality or for which consumers have certain comfort preferences such as being portioned or filleted. Some serve a mixture of local and imported seafood and some, mainly supermarkets, only sell imported seafood [14].

Other initiatives
In Annex 2 "Running projects on Bonaire in relation to agriculture" an overview of agriculture-related initiatives on Bonaire is listed.

[9] Source: mail Punta Blancu Farms d.d. 2022-09-19

3.2 Tourism

In 2013, Bonaire had almost 340 tourist accommodations, of which 40 percent were villas, 32 percent apartments, 14 percent hotels and resorts and 14 percent holiday homes[10]. The total bed capacity was around 5,500 beds. It should be noted here that it was sometimes not clear whether all the homes of a holiday park were offered for rent, or only a part of them. Also, villas that are for sale were often still offered as holiday homes. Most sleeping places were offered in the hotels and resorts (48 percent), followed by villas at 24 percent. Apartments provided 19 percent of the beds, and vacation homes 10 percent. There were 120 restaurants in 2018[11].

Table 4 Number of airline passengers to and from Bonaire (CBS, Statline).

Flight passengers	Arriving passengers	Departing passengers
2018	180,570	178,780
2019	191,960	192,490
2020	79,930	80,530
2021	130,200	129,680

Table 5 Number of cruise passengers (CBS, Statline).

Year	Cruise passengers (x 1,000)
2018	397.1
2019	457.7
2020	176.1
2021	56.6*

*=preliminary figures.

Figure 5 Cruise ship with 1100 passengers arrives in Bonaire port in Sept. 2021 [10].

3.3 International trade

Bonaire's port facilities consist of the Bopec (Bonaire Petroleum Corporation) terminal, the Kralendijk Port (for bulk cargo, containers and cruise ships), the Cargill Salt Company Terminal (bulk salt) and the Valero Airport Pier (kerosene supply for Flamingo Airport). There is no ferry for passenger transport to/from any of the other islands. In 2017, a total of approximately 177.5 million kg of goods was imported by sea, where

[10] https://www.cbs.nl/nl-nl/achtergrond/2014/23/toerisme-caribisch-nederland-2012, gezien 2-5-2022
[11] https://www.sunrentalsbonaire.com/nl/posts/10-beste-restaurants-op-bonaire/#:~:text=Met%20zo'n%20zo'n,hebben%2C%20Bonaire%20heeft%20het%20allemaal, gezien 2-5-2022

more than 135 million kg of goods was exported. The majority of goods on Bonaire come via Curacao and are transported by (only) one shipping company (see Chapter 4).

The port in Kralendijk is too crowded at the moment, and a new (small-scale) freight port may be developed near Hato, but the decision has not yet been made (2023). A cargo port makes direct reception possible from container ships from Europe, South America and the United States so that the goods destined for Bonaire no longer have to take a time-consuming and cost-increasing detour via Curaçao [12].
An overview of the international trade is shown in Table 6. In Annex 1 ("Import Bonaire 2020") some statistics are presented, but these are incomplete, since the flow from the US to Bonaire enters Curacao first, and statistics from the trade between Curacao and Bonaire could not be obtained.

Table 6 Purchase and sales channel for imported goods in Bonaire including countries of origin.

Product categories	Purchase/sales	Sourcing area
Cereal products		
Rice	Purchase from wholesalers Curaçao or EU/US; Sales through local supermarkets	Main country of origin is USA. In addition, also import from other Brazil, India and Thailand.
Flour	Purchase from wholesalers Curaçao or EU/US; sales through local supermarkets	Mainly from Jamaica, US and Colombia.
Bread	Purchasing ingredients at wholesalers Curaçao, sometimes directly from the Netherlands (baked bread). Selling local bakeries through their own store, but also through the grocery store.	Mainly from Jamaica, US and Colombia.
Cake, pastry and pretzels	Purchase from wholesalers Curaçao and straight from the Netherlands	Offer of cookies, pastries and pretzels is very diverse with various origins.
Fruits and vegetables		
Fresh fruit (apples and oranges)	Purchase at wholesalers Curaçao, or purchase through our own wholesaler. Sales through local supermarkets.	Vegetables also come mainly from the US and Europe (Netherlands). The regions of origin of the fruit are more diverse.
Fresh vegetables (tomato and bell pepper)		
Dairy		
Cheese	Purchasing at wholesalers Curaçao or via own wholesale, sales through local supermarkets.	Dairy products are mainly sourced in Europe. For cheese, this is mainly the Netherlands. For milk there are more providers, for example from Belgium, Netherlands and Germany.
Milk		
Meat		
Poultry	Purchase from wholesalers Curaçao; sales through supermarkets	Chicken on Curaçao is mainly imported from Brazil, the United States and from China. Cans corned beef comes mainly from the US and Europe.
Meat products and meat dishes		
Fruit juices and water		
Fruit and vegetable juices	Purchasing at wholesalers Curaçao and through own wholesale. Sales through the supermarkets	Sourcing is very diverse (including Dominican Republic, United States, South Africa, Panama and Brazil.
Mineral water		There are a number of regional brands. More expensive (brand) products are mainly supplied from Western Europe.

4 The food supply chain

Most products sold by supermarkets and tokos on Bonaire come from the United States (particularly via Miami), Western Europe (including Rotterdam) and Latin America. The goods concerned are partly purchased directly at the producer and then delivered by container (via Curaçao). Other more specific products are purchased from wholesalers in the area of origin. In the Netherlands these are, for example, NL Food, van Tol and AG Holland. All the information in this chapter has been retrieved from [17].

Wholesalers:
Many supermarkets on Bonaire buy (a part of) their products at the wholesalers on Curaçao. These wholesalers often send agents to Bonaire who come to take the orders. The supplied products from elsewhere are processed separately and transported (by container) via the logistic service provider Don Andres to Bonaire.
Wholesalers located on Curaçao often also work with agents on Bonaire who take the orders at the supermarkets. In addition, on Bonaire itself there are some wholesalers active. For example, the Van den Tweel Group on Bonaire has acquired the wholesaler Bonaire Food Group. This wholesaler supplies both high-quality fresh products and long-life products at both supermarkets of the Van den Tweel Group on Bonaire (Van den Tweel Supermarket and Discount Warehouse). A more specialized wholesaler is Best Brands who is the official importer of Coca Cola for Bonaire and also other soft drinks and alcoholic beverages including wine, beer and spirits across Bonaire. Supermarkets are increasingly also importing goods themselves, outside the existing wholesaler. Via the so-called parallel import, thereby benefiting from the (sometimes) considerable price differences between countries.

Logistic service provider:
An important link in the value chain is the transport of the containers from Curaçao to Bonaire (and vice versa). In the current situation, Bonaire does not have the necessary port facilities, because the number of containers is modest. The transport of the containers between Curaçao and Bonaire is provided by the local transport company Don Andres. The company has two ships that sail 3 to 4 times a week between both islands. Due to the lack of a crane on Bonaire, the loads are transported on board or disembarked. The maximum capacity of the ships used is 15 (40 ft) containers. If this is we extrapolated on an annual basis, the maximum is roughly about 2,500 to 3,000 containers that are transported to Bonaire (and vice versa) annually. Because not all capacity is actually used, the number of containers will be lower in practice. On the route, Don Andres is currently the only provider. The relatively small cargo volume between Bonaire and Curaçao and the need to transport containers by axle has a price-increasing effect. Upon arrival in the port of Bonaire, the containers are driven off the ship . For smaller customers, Don Andres usually also takes care of the administrative actions that are required for importing the goods (customs clearance). The larger supermarkets take care of the customs clearance themselves. On request, Don Andres also delivers the containers/goods to the customer on the island.

Supermarkets/food shops:
On Bonaire there are a few large and several smaller supermarkets in and around Kralendijk. The largest are: Van den Tweel supermarket, Warehouse Bonaire (both from the same owner), Bondigro supermarket, Famoso supermarket, Sunshine Market and Lucky Supermarket. Remarkable is that all these supermarkets are located at a very short distance from each other. Other supermarkets in and around Kralendijk are Top Supermarket and Wing Cheung Supermarket. In addition, all kinds of mini-markets are located on the island, which are almost always Chinese owner and operated. The catchment area of these mini-markets is often the surrounding neighbourhood. It is often possible for regular customers to buy on credit. Due to the small catchment area, the mini-markets are often more expensive than the large(r) supermarkets. In order to achieve sufficient turnover, the minimarket is often combined with a simple bar/restaurant (a so-called "snack") where the emphasis is on drinking beer, but where you can usually eat in or take away. On Bonaire, the arrival of Bondigro opened up the market. Bondigro has a cooperative structure and puts especially on offering products as cheap as possible at the highest possible price quality. Gradually, Bondigro has expanded the range of supermarket products to include tanning white goods and recently also furniture.

The description of the food supply chain provides insight where organic waste flows can be found. The information in this chapter is used for interviews, data collection and upscaling on results on organic waste on Bonaire.

5 Policy

Although local agriculture and livestock farming were historically important, in the Caribbean Netherlands, it is now a marginal economic sector. To improve the quality of the landscape (competing for land with resorts, hotels and housing) while stimulating local economic development and increasing food security, investment in local food production is necessary.
Currently, the local and national government are making efforts to professionalize livestock farming and to reorganize the local agriculture department on Bonaire by 2024 into fully operational information centers for innovative agricultural production. Infrastructure, such as a water supply and functioning markets, must be in place to increase the capacity for circular agriculture and livestock farming [18].

There is a program from 2013-2023 on waste management (Afval Beheer Programma), with a budget of 10 million USD. It contains 20 projects, 6 on policy and 14 on capacity building (equipment, people). The program was submitted to the Ministry of Infrastructure and Water Management by Selibon and OLB. Currently, the project is recalibrated financially, and also combined with other budgets from an Environmental Policy plan. The latter has a focus on nature conservation rather than waste management, but clearly both are related. In this context the annual budget of the Ministry of Agriculture, Nature and Food Quality, approximately € 1.3 million is reserved for nature conservation and management in the Caribbean Netherlands. In addition to the regular budget, €1.5 million has been allocated for the period 2020-2024 for the implementation of this plan, of which €0.5 million is specifically earmarked for quality improvement in the national parks [18]. However, until now, no projects nor targets are related to circularity of organic waste.

Waste policy [18] priorities:

a) Complete end to illegal landfill (2030)
b) Total end to landfill thanks to investments in advanced waste treatment and recycling (2030)
c) Controlling the leakage of pollutants from existing landfills to soil and surface water (2030)
d) Investing in companies that use plastic/solid waste to manufacture new products (2024)
e) Ban on single-use plastic (2024), resulting in less plastic waste (e.g., no plastic packaging of fruits and vegetables in local supermarkets and food stores)
f) Regulation and enforcement of waste separation in industry and households (2024)
g) Monitoring marine litter and promoting the cleaning of marine and coastal areas where plastic accumulates (2024)
h) (Fiscal) incentives and enforcement for compliance with the waste management policy (2030)

Investing in sustainable local food production [18]

a) Facilitating the sustainable use of waste water and other potential waste streams (e.g. compost) for agricultural production (2024)
b) Developing infrastructure and capacity to stimulate consumption and production of local fruits and vegetables, animal feed and other commercial crops (2024)
c) Infrastructure development and incentives to stimulate demand for local agricultural products (2024)
d) Develop an island-wide strategy to promote circular production in line with EU circular economy strategies (2030)
e) Promote research and investment in salt-resistant crops, as well as the cultivation of algae and seaweed (2030)
f) Launch integrated rural development projects to create buffer zones with sustainable forms of agriculture near nature reserves (2030)
g) Developing guidelines and promoting best practices for sustainable agriculture (2024)

As mentioned in Chapter 2.1 (“Agriculture”, section Horticulture), in 2019/2020 it was decided to convert LVV into a knowledge center and to develop the terrain from LVV into a business center for agro-entrepreneurs. The plan is that plots will be issued to private parties and to assist them with expertise, information and research. LVV has started recruiting private parties who can cultivate fruit and vegetables at the LVV site.

6 Organic waste flows

Waste collection and disposal on Bonaire is managed by the local government. Twenty years ago, the Executive Council of the Island Territory Bonaire decided to make a new company called Bonaire Management Group N.V. (BMG) responsible for this task. The partner BMG was approved by the Executive Council of the Island Territory Bonaire in the year 2000 and includes the organization SELIBON that is responsible for waste collection and waste management. With the exception of a few remote kunukus, SELIBON's working area covers the entire 294 square kilometres island. Waste collection service is provided to 9000 households and 500 companies [11]. A large part of these companies are directly or indirectly active in tourism, e.g., hotels, resorts, restaurants and car rental companies. In addition, there are a number of contractors engaged in government tasks, services, shops, construction and project development activities, vehicle repair, etc. Special attention is paid to waste from the hospital, the laboratories, the dental practices, the veterinary practices and the slaughterhouse where (bio)medical and offal respectively are offered. SELIBON has recycling parks in Kralendijk and Rincon. At Lagun there is a waste center. There will be a new facility next year (2024) to store waste oil. The glass that is collected is crushed so that it can be used in construction as a filling for foundations. Metal and, for example, batteries go to Asia for recycling. Cardboard goes that way too. In addition to the Lagun waste dump (Fig. 6), waste is also collected at the Morotin dump. This is an illegal landfill for the Rincon region, without any kind of supervision and facilities, that is tolerated by the local government.

Currently the landfill at Lagun is 24 meters high, whereas the limit is 25 meters. Action is required to find alternative disposal methods. The current project has partially resulted from this issue.

Figure 6 Top of the landfill pile at Lagun (source: Han Soethoudt, WUR).

The vision of Selibon N.V. is to deposit only 65% of the total waste at the landfill by the year 2024 and the intention is to recycle or otherwise process approx. 40% of the waste. An example is the cooperation between Selibon and the Bonaire Hotel and Tourism Association (Bonhata), that aims to separate waste from the tourism sector as much as possible at the source[12].

[12] https://antilliaansdagblad.com/bonaire/24458-toeristensector-bonaire-gaat-afval-beter-scheiden-2, viewed 28-7-2022

6.1 Types of organic waste flow

In the current study the focus is on organic waste, and an overview of these flows is shown in Table 7 (based on interviews with Selibon June 6th 2022, Bonaire and WEB June 8th 2022, Bonaire).

Table 7 Overview of all types of organic flows on Bonaire and their waste management.

Source waste	Waste type	transport	Destination	Remark
Household	Residual waste	Collected by Selibon	Landfill	Sometimes plastic, cardboard supplied separately
Household / Out of home	Used cooking oil	Transported to Selibon	Netherlands for biodiesel	
Restaurants/Hotels	Residual waste	Collected by Selibon (different from household)	Landfill	
	Food waste	Farmers/ Kunuku people come and collect	Animal feed	
Slaughterhouse	Big cadavers		Buried	Too large for oven
	Small cadavers	Collection service available at Selibon	Buried	
	Animal waste	Transported to Selibon or collected on request	Incinerated	
Chicken farm	Manure	Not applicable	Buried	
Goats	Manure	Not applicable	Remains on land	Partly collectable
Horticultural production	Plant and product waste	Not applicable	?	Negligible amount
Cruise ships	Residual waste	Transported to Selibon by external logistic company	Landfill	
Supermarkets/food shops	Organic waste	Farmers/ Kunuku people come and collect	Animal feed	Amounts are low
Hospital	Medical waste	Collected separately by Selibon	Incinerated	
Various sources	Pallets/wood		Landfill	Very irregular
Import	Rejected food	Collected by Selibon on request		Destination depends on type of food (meat vs fruit, vegetables, grain)
Ocean	Sargassum	Transported to landfill Lagun by Stinapa (Stichting Nationale Parken Bonaire)	Landfill	Sargassum waste contains lots of sand
WEB	Sewage sludge	Transported by WEB to Selibon	Landfill	

As described in Table 7 organic waste flows are either collected (e.g. households once a week) by or delivered to Selibon. The waste collection from companies (restaurants, hotels,...) is based on frequency rather than waste weight. Only the final waste weight in a truck is monitored when dropping the total amount that is collected from one route. Hence, the amount of waste per restaurant or hotel is not clear. Selibon uses other trucks in this case than for households. Sewage sludge is taken to landfill and dumped together with contaminated soil (other contaminated soil from WEB, LVV, Curoil and other sources is also landfilled).

In addition there are organic flows that are not processed by Selibon. Households may use it as animal feed, and at supermarkets, restaurants and hotels it is collected by farmers or people from the kunukus, probably for animal feed as well.

If Selibon is looking for circularity, trying to optimize valorisation options, it is necessary to elaborate a business case. Crucial elements in such a business case are the composition and insight when, and how much of an organic waste flow becomes available. The composition can be determined by sample analysis, a topic that is discussed later on. Typically, regularity is an issue when waste flows are not collected by Selibon

on a regular basis. Investments in facilities processing organic waste are troublesome if part of the year the machines are idle. This is e.g. the case for Sargassum, that generally arrives on the Bonaire beaches between April and July. The Sargassum is crossing the Atlantic Ocean, coming from West Africa, covering beaches. It has negative effects on tourism and causes environmental damage. NGO Stinapa is responsible for cleaning the beaches, but costs are high and some beaches are not accessible for heavy machinery and trucks making the cleaning process more expensive or impossible. A lot of effort in the current project is put into solving the Sargassum problems, by avoiding sargassum beaching and trying to find feasible applications for sargassum (see Work Package 2 - 6 of the BonCirc project).

At Selibon there are differences in containers with respect to type of waste (colour) and type of supplier of waste (size is different for e.g. household vs company). This is shown in Figure 7.

Upper left: company containers (large, collect)	Upper right: household containers (small, collect)
Lower left: frying fat (bring)	Lower right: cardboard

Figure 7 Public waste station Selibon at Kaya Industria (source: Han Soethoudt, WUR).

Not only at the Selibon station, but also in populated regions waste can be brought to containers separated by type, see Figure 8.

Figure 8 Containers with separation options for plastic, can, paper/cardboard and glass (source: Han Soethoudt, WUR).

6.2 Data on organic waste flow

About 10 years ago, no reliable waste statistics were available on Bonaire. In the past 5 years Selibon has professionalised the data collection and the level of detail is increasing (Table 8).

Table 8 Overview of Selibon waste statistics from Lagun in 2021.

Source of waste stream	type of waste	weight in 2021 (tons)
Household*	residual waste (HKAL)	6102
Companies (hotels/restaurants/...)*	residual waste (RTAL)	2365
Households and companies	garden waste	3572
Slaughterhouse*	animal waste (AEPN)	94
Hospital and similar	medical waste (SKZSKAL)	36
Import (processed by Selibon on demand)	residual waste (green)	94
	residual waste (animal)	
Inhabitants Bonaire	small cadavers private	33
Variable sources* (residents, companies, ...)	wood/pallets (irregular)	548
Sea	Sargassum	589
WEB**	sewage sludge	192

*= Data are available on daily, weekly, monthly basis as well.

**= Data can be collected per month from WEB (now the total is calculated as 12 x 16 = 192 tons/y)

Remarks:

- If (any) waste from cruise ships is delivered to Lagun, the weight is incorporated in RTAL, which is the company residual waste. These data cannot be split.
- Imported products that are rejected by retailers or resorts can be plant and animal based, and are collected on demand by Selibon for disposal.
- The amount of Sargassum collected from beaches is unclear. In 2021 Selibon registered 589 tons, and in 2022 about 1798 tons until June already. But, the Sargassum was significantly contaminated with a.o. sand[13]. More precise data should be derived within the project (see Work package 2). Note that according to insiders only 10% of the Sargassum that is beached can be collected by STINAPA. The other beaches cannot be reached with Bobcats nor trucks nor other equipment.
- Garden and food waste is mostly garden waste and collected from entities responsible for maintenance of parks and public gardens.

As shown in Table 9 for some of the largest flows the weights are available at Selibon on a smaller timescale as well, which is important for the business case.

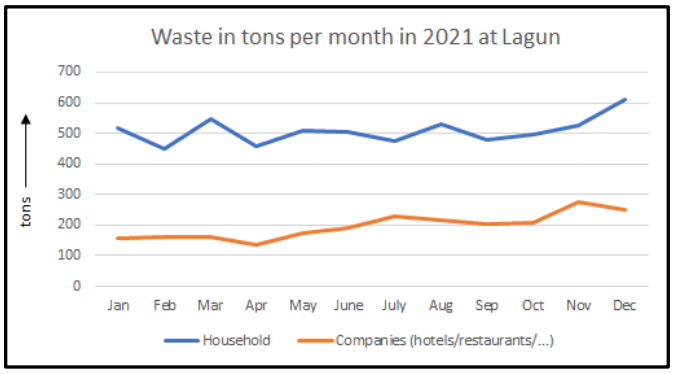


Figure 9 Graph showing the waste flows on Bonaire in 2021 per month.

The monthly amount of waste is shown in Figure 9. For households it varies between 450 and 550 tons per month, except for a small increase that is detected at the end of the year (Christmas and New Year). For

[13] Observed by project team on June 6 2022 in Lagun

companies the collected waste varied between 135 and 275 tons per months. There is an increase during summer and a peak at the end of the year. Data collection was professionalized since 2018 and trends over the years are difficult to derive, mostly because of COVID-19 and the major impact of this pandemic on the number of tourists. So, annual data are available but cannot be used for trend analysis. Data can be split up in weeks or months as is shown in the Table 9 (not available for all types of waste).

Table 9 Data (in tons) on a monthly basis in 2021 (Selibon).

Source of waste stream	Households	Companies (hotels/restaurants/...)	Slaughterhouse	Hospital and the like	Variable source (residents, companies,...)
type of waste	residual waste (HKAL)	residual waste (RTAL)	animal waste(AEPN)	medical waste	wood/pallets
destination	landfill	landfill	incineration	incineration	landfill
Jan	515.42	158.99	16.51	1.58	40.62
Feb	449.98	159.92	4.52	1.09	28.95
Mar	547.15	161.26	16.42	3.16	37.84
Apr	457.75	135.25	5.9	7.14	41.02
May	509.08	175.74	17.14	2.92	38.82
Jun	506.39	192.16	3.58	3.63	34.44
Jul	473.46	231.18	2.6	2.25	52.17
Aug	531.66	215.26	6.16	1.57	54.3
Sep	479.06	201.73	9.22	2.13	50.84
Oct	495.17	209.34	4.26	3.46	46.14
Nov	526.04	274.02	2.94	2.58	66.26
Dec	610.76	249.7	5	4.44	57.08
Total 2021	**6101.92**	**2364.55**	**94.25**	**35.95**	**548.48**

6.3 Composition of organic waste flows

The composition of the waste flows is an input for the evaluation of valorisation options. Composition can be determined on two dimensions: firstly, in waste categories like glass, paper, wood, organic. This is relevant since unmixed organic waste as such is hardly available. The goal of this study is to go one level deeper into the composition of the organic waste to make valorisation options more targeted. The second dimension is about nutrients and chemicals, and requires lab analysis.

6.3.1 Data from literature

About 10 years ago, research was carried out on behalf of Selibon NV into the composition of the household waste **produced** on Bonaire. Results are shown in Table 10 (in Dutch) [19].

Table 10 Results of household waste sorting analyses 2011 and 2012 (for comparison the percentages for The Netherlands in 2010).

Afvalfracties (gemiddeld over 9 Bario's (woonkernen))					
Fracties	**2011**		**2012**		**2010 (NL)**
	Totaal	Gemiddeld	Totaal	Gemiddeld	
	Kg	%	Kg	%	%
GFT-afval*	516.96	8.5	981.15	17.79	37.0
(Herbruikbaar) papier en karton	926.61	15.2	852.5	15.46	22.0
Glas	710.07	11.7	650.3	11.79	4.3
Textiel	396.13	6.5	379.95	6.80	3.6
Kunststoffen	1276.60	21	768.6	13.93	14.0
Metalen	149.37	2.5	188.05	3.41	4.0
Hout	118.26	1.9	78.15	1.42	
Steenachtige materialen/puin	131.56	2.2	56.3	1.02	
Klein chemisch afval	26.00	0.4	43.35	0.79	0.03
Wit- en bruingoed	110.34	1.8	133.65	2.42	
Overig/residu	1340.85	22.1	1097.5	19.89	8.0
Drankkartons	66.86	1.1	49.8	0.90	
Hygiënisch papier (luiers)	197.11	3.2	166.2	3.01	6.6
Piepschuimbakjes (snacks)	112.05	1.8	75.5	1.37	

The details of this measurement could not be traced. There is an important distinction between household waste *produced* and household waste *collected*. The destinations of the waste flows in Table are not mentioned, which turns out to be crucial in the quantification of organic waste available at Selibon.

This kind of sorting analysis should take place on a regular basis, not only for valorisation but also for policy making on waste collection and waste management.

A first analysis of the composition of industrial waste was carried out at the beginning of 2013. The outcome of this sorting analysis can be found in Table 11 [19] . These data are a one day sample and hence should be treated with care.

Table 11 Composition analyses of industrial waste on Bonaire in 2013.

Sorting analysis Businesses. From 14 Jan till 18 Jan 2013

	14 Jan '13		15 Jan'13		16 Jan '13		17 Jan '13		18 Jan '13					
Business	Restaurant		Hotel Resort		Office		Supermarket Shop		Rest Business		100			%
	kg	%	kg	%	kg	%	kg	%	kg	%				
Garden	38,55	4,09	43,45	3,81	49,85	6,28	39,75	5,43	0,00	0,00	*171,60*		Garden	4,19 %
Kitchen	106,55	11,30	145,25	12,72	54,15	6,82	101,05	13,80	23,10	4,79	*430,10*		Kitchen	10,51 %
Paper / carton	125,15	13,27	129,00	11,30	289,90	36,52	156,65	21,39	135,35	28,05	*836,05*		Paper / carton	20,42 %
Glass	385,55	40,90	221,00	19,36	67,50	8,50	136,65	18,66	9,45	1,96	*820,15*		Glass	20,04 %
Clothes / Textile	3,50	0,37	26,55	2,33	10,40	1,31	14,90	2,03	0,00	0,00	*55,35*		Clothes / Textile	1,35 %
Plastics	94,90	10,07	150,60	13,19	84,40	10,63	110,35	15,07	101,00	20,93	*541,25*		Plastics	13,22 %
Metal	26,95	2,86	20,60	1,80	12,70	1,60	16,65	2,27	2,45	0,51	*79,35*		Metal	1,94 %
Wood	0,00	0,00	44,60	3,91	3,60	0,45	0,00	0,00	11,40	2,36	*59,60*		Wood	1,46 %
Concrete material	0,00	0,00	0,00	0,00	27,05	3,41	25,50	3,48	0,00	0,00	*52,55*		Concrete material	1,28 %
Chemical waste	1,40	0,15	4,80	0,42	1,55	0,20	2,35	0,32	0,00	0,00	*10,10*		Chemical waste	0,25 %
Equipment	0,00	0,00	8,90	0,78	51,35	6,47	4,35	0,59	38,20	7,92	*102,80*		Equipment	2,51 %
Rest	0,00	0,00	18,70	1,64	4,85	0,61	20,10	2,74	0,00	0,00	*43,65*		Rest	1,07 %
Drinking cartons	7,50	0,80	9,70	0,85	2,70	0,34	4,80	0,66	1,05	0,22	*25,75*		Drinking cartons	0,63 %
Diapers/hygienic	2,15	0,23	5,35	0,47	2,65	0,33	3,65	0,50	130,50	27,04	*144,30*		Diapers/hygienic	3,53 %
Foam	0,85	0,09	7,65	0,67	8,00	1,01	10,10	1,38	5,10	1,06	*31,70*		Foam	0,77 %
MIX (>4 cm)	96,35	10,22	74,15	6,49	26,20	3,30	41,45	5,66	12,50	2,59	*250,65*		MIX (>4 cm)	6,12 %
4 cm > x > 1 cm	51,30	5,44	127,90	11,20	39,40	4,96	31,90	4,36	8,70	1,80	*259,20*		4 cm > x > 1 cm	6,33 %
Waste Fraction														
< 1 cm	2,05	0,22	103,60	9,07	57,65	7,26	12,10	1,65	3,80	0,79	*179,20*		< 1 cm	4,38 %
												100		
Total	942,75		1141,80		793,90		732,30		482,60		4093,35	kg		
Total weight	2840 kg		1600 kg		1160 kg		820 kg		1080 kg					

Other specific waste flows are understood to mean those wastes that are separated offered and/or which, in terms of nature and composition, require special attention for the processing and/or the possibilities for reuse. These specific waste streams can be found in [19], but the organic waste flows are summarized below (with relatively old data):

- Wood: In 2010, approximately 200 tons of wood waste was collected. It is unclear what the origin and quality of this waste stream was
- Offal: In 2011, approximately 70 tons of offal and carcasses were collected

6.3.2 Data from measurements and interviews

In the context of valorisation there is interest in more detailed information on the organic flow. Hence, to update the food waste quantification data, measurements were conducted and interviews were held, the latter for companies only.

6.3.2.1 The measurement of household and company waste

The waste measurement of households and companies was carried out by Melinda Marchena (Selibon) and Christle Nieuw (student Wageningen University) at the Selibon landfill location. The design and the setup of the measurements are described in detail in Annex 6 ("Set up of measurement").

Figure 10 Excavator separating waste for composition analysis (source: Christle Nieuw).

The results of the measurements are listed in Table 12.

Table 12 Results of composition analysis of HKAL=household waste and RTAL=company waste in kg and %.

Weight (kg)	May 9 HKAL – Playa Pariba	May 10 HKAL – South	May 11 RTAL - companies	May 12 RTAL - companies	Total	%
Starch products	0	0.5	0	0.5	**1**	**0.2**
Meat and fish	0	0.5	0	0	**0.5**	**0.1**
Fruit & Veggies	0.5	0	5.5	0.5	**6.5**	**1.2**
Bread	0	0.5	0	0.5	**1**	**0.2**
Dairy	0	0	0	0.5	**0.5**	**0.1**
Sauce	0	0	0	0	**0**	**0.0**
Groceries	0	0	0	0	**0**	**0.0**
MISC	0	0	0	0	**0**	**0.0**
Garden waste	0.5	6	1.5	0.5	**8.5**	**1.6**
Total	1	7.5	7	2.5	**18**	**3.4**
Recyclables	139	133	113	119	**504**	**96.6**
Total	139	133	113	119	**504**	**96.6**
Total kg	140	140.5	120	121.5	**522**	**100.0**

The percentage of organic waste was 3.0% (=8.5/280.5) in household waste and 3.9% for companies. In the Netherlands, for households in 2022, these percentages were 20.6% in the grey garbage bin ('restafval') and 17.3% in the green garbage bin ('GFT')[14], when inedible and edible parts are combined.

[14] Monitor Voedselverspilling Nederland 2009-2022, (yet) internal document by Han Soethoudt, Martijntje Vollebregt

The team noticed that according to several inhabitants and Selibon employees, it is not common to dispose organic waste in Bonaire. If organic goods may not be consumed for whatever reason, it is preferred to use as animal feed or for pets such as dogs, cats, donkeys, goats, etc. or to fertilise, or dispose of in the gardens. This explains why organic waste fraction is so low. Another factor that may affect general organic waste at the landfill are that dogs, goats, and seagulls were seen eating from the waste.

6.3.2.2 Data on organic waste from companies

At the end of August 2022 Bonhata sent out a questionnaire to their members on behalf of the project to get information on the waste amounts produced and mode of disposal. There was only one response, which was qualitative only. Hence, no relevant results could be retrieved. The hotels, etc. don't pay for the weight of waste disposed, but for the collection frequency. This means that Selibon has no info on amounts of waste collected per client.

In 2023 interviews with companies were carried out by Sabine Engel who lives on Bonaire. The results are presented anonymously in Table 13.

Table 13 Results interviews on organic waste with some companies.

Company type	Organic waste category	Amount	Destination	Comment
Supermarket 1	Vegetables/Bread		Donkey shelter	
	Dairy		Selibon	
Supermarket 2	Vegetables	5 kg/day	Kunukeros	
	Bread			
Supermarket 3	Vegetables	10 kg/day	Selibon	Sometimes Kunukeros
	Dairy	4 kg/day		
	Meat	5 kg/wk		
Importer/distributor	Vegetables/Bread	200 – 500 kg/wk	Kunukeros	
	Meat		Selibon	
Restaurant	Kitchen waste			
Resort				Used coffee grounds are collected separately

These data are quite random and indicative, and cannot be used for investment calculations. Note that in the Netherlands the average amount of organic supply to an anaerobic digestor is about 40,000 tons, equivalent to 800 tons/week, which is 1000 times as much as seems to be available at the companies in Bonaire.

6.3.2.3 Trade waste

At the port in Bonaire there is no HOI ('Havenontvangstinstallatie'). This is a facility in a port that can accommodate oil, waste and chemical residues from ships, in order to minimize illegal discharges in ports and environs. Checking imports is not a very clear process, concluded even after contacting some of the logistic companies involved in this business on Bonaire.

- Robert Croes from Rocargo Services: Rocargo deals with non-food mainly, and their only contribution is clearing goods. Containers remain sealed and are transported to the retailer.
- Jancarlo de Jong from Don Andres: same story as Rocargo
- Edward Thielman from Customs on Bonaire: the inspector of the veterinary service is responsible for meat import, plants are checked by LVV

As a consequence rejections are scarce at port level, and merely take place at the premises of the receiving company.

6.3.3 Summary literature and new data collection on organic waste

As noted earlier, there is a difference between what is produced as waste and what ends up at Selibon. The measurements showed that much of the organic waste, although produced on Bonaire, is not collected by Selibon. Hence, the volume available for better validation (i.e. collected or easy to collect by Selibon) is very limited as shown in Table 14.

Table 14 Estimate of annually produced organic waste on Bonaire.

	Year	Waste flow information	products	organization
1	2023	6,102 tons (Table) household waste x 3% = 183 tons	GFT[15] waste	Selibon collects from households
2	2012	4,000 tons household waste x 15.33% = 613 tons	Paper and cardboard	Selibon collects from households
3		4,000 tons household waste x 1.66% = 66 tons	Wood	Selibon collects from households
4	2023	3,572 tons (Table)	Garden waste	Waste transported by households and companies to Selibon
5		2,365 (Table) company waste x 3.9% = 92 tons	GFT waste	Selibon collects from hotels, restaurants, resorts, supermarkets
6	2023	1,200 tons	Chicken manure	Farm Punta Blanku
7	2023	2,000 tons	Goat manure	Goats that are not free
8	2013	120 restaurants x 300 days x 125.15 kg per day = 4505 tons	Paper/cardboard	Restaurant
9		48 hotels/resorts x 300 days x 129 kg per day = 1842 tons		Hotel/resort
10		45 supermarkets/shops x 156.65 kg per day = 2115 tons		Supermarket/shop
11		0	Wood	Restaurant
12		48 hotels/resorts x 300 days x 44.6 kg per day = 637 tons		Hotel/resort
13		0		Supermarket/shop

Remarks on calculations:

1. The 3% is mentioned in the text below Table
2. The 4,000 tons are from [19], and 15.33 is the average of 15.2 and 15.46 in Table
3. The 4,000 tons are from [19], and 1.66 is the average of 1.9 and 1.42 in Table
4. Clear
5. 3.9% is mentioned in the text below Table
6. 1,200 tons is taken from paragraph 3.1
7. 2,000 tons is taken from paragraph 3.1
8. 125.15 kg is taken from Table (column 'Restaurant')
9. 129 kg is taken from Table (column 'Hotel')
10. 156.65 kg is taken from Table (column 'Supermarket')
12. 44.6 kg is taken from Table (column 'Hotel')

[15] GFT = Groente-, fruit- en tuinafval = vegetable, fruit and garden waste

6.3.4 Lab analysis of seaweed

The second level of composition analysis is related to nutrients and chemicals. To identify feasible valorisation options this information is crucial, but not much research is done in this area yet. Only for sargassum and sewage sludge detailed analyses were carried out. The results for Sargassum on Bonaire are from [20]. More details can be found in the same reference.

Table 15 Sargassum content of elements, ash and protein. Total characterised is the sum of sugars and uronic acids, protein and ash [20].

Sample		1	2	3	4	5	6	7
Component		Bonaire, Lagun	Bonaire, Lac Bay	Florida	St. Maarten, open sea	St. Maarten, open sea	St. Maarten, Point Blanche bay	St. Maarten, Guana Bay
C	%DW	27.0	24.2		27.9	29.8	21.6	21.9
H	%DW	3.8	3.5		3.7	3.4	2.0	2.7
N	%DW	1.2	1.2		0.8	0.9	0.7	1.3
Ca	g/kg	50.4	56.0					
K	g/kg	60.8	62.9					
Mg	g/kg	10.9	12.0					
Na	g/kg	34.1	46.9					
S	g/kg	15.1	14.8					
Ash	%DW	42.5	47.5	36.8	35.2	36.1	67.8	48.6
Protein	%DW	6.2	5.8		3.8	4.5	3.4	6.5
Total characterized	***%DW***	***74.9***	***79.8***	***71.9***	***69.1***	***76.1***	***79.4***	***66.8***

For the sewage sludge WEB sent samples to the research lab Aqualis in Zwolle, the Netherlands. For RWZI the composition is shown in Table 16. The sample was taken in March 2022. The estimated amount of sewage sludge produced yearly at WEB is 192 tons (dry matter).

Table 16 Composition of sewage sludge at WEB, Bonaire[16].

Anorganisch					
Droge stof	26.3	%			
Stikstof (Kjeldahl (als N))	69	g/kg ds			
Totaal fosfor (als P)	19	g/kg ds			
Metalen					
Aluminium	7.9	mg/kg ds	Molybdeen	9.8	mg/kg ds
Antimoon	1.3	mg/kg ds	Natrium	2.7	mg/kg ds
Arseen	4	mg/kg ds	Nikkel	30	mg/kg ds
Barium	110	mg/kg ds	Telluur	< 1	mg/kg ds
Cadmium	1	mg/kg ds	Thallium	< 1	mg/kg ds
Calcium	29	mg/kg ds	Tin	54	mg/kg ds
Chroom	43	mg/kg ds	Vanadium	38	mg/kg ds
IJzer	14	mg/kg ds	Zilver	17	mg/kg ds
Kobalt	5.9	mg/kg ds	Zink	760	mg/kg ds
Koper	220	mg/kg ds	Zwavel	9.8	mg/kg ds
Kwik	0.97	mg/kg ds	Kalium	3.8	mg/kg ds
Lood	16	mg/kg ds	Magnesium	8.4	mg/kg ds
Mangaan	280	mg/kg ds			

[16] Data received from WEB

7 Waste treatment

The official waste dump on Bonaire is Lagun, currently composed of an estimated 1,000,000 m^3 (approx. 500,000 tons) of waste. Since at present the reuse of waste is very limited most of the collected waste is landfilled. The exception to this is waste oil. Also, for two years there has been a partnership between Selibon NV and the private party BonRecycling. On a limited scale, construction and demolition waste is made suitable for local reuse. There is no reuse of organic waste at Selibon.

In principle, the household waste is collected using DIN-containers (is the same as the 'grijze bak' in NL) of different sizes (240, 1,000 and 1,100 litres). These are loaned to private individuals and rented out to businesses. In general, there is mixed collection of residual waste. Only on limited scale an organized, separate collection of paper and glass at a number of companies is in place. Garden and pruning waste are generally offered separately and there are also some small-scale private initiatives for the separate collection and processing of specific waste streams, such as batteries and cartridges.

On Bonaire, paper and cardboard, plastic, glass and metals (including tin) from many companies is already collected separately for recycling [11]. At a large number of contractors, industrial waste is collected within the regular collection of the household waste. This also makes it difficult to make a thorough estimate of the quantities of household and commercial waste actually produced. Incidentally, in the law VROM BES, the distinction between household waste and commercial waste has become obsolete, precisely because the nature of the waste is largely the same. Household and commercial waste is collected by means of so-called press squat trucks.

The slaughterhouse generates organics waste flows as well. Some time ago, goats were mainly slaughtered at home and the internal organs were also eaten. The head was kept for soup, while the liver (higra) and lungs (boffie) were also used for special dishes. The intestines were used for the dish "mondongo". Nowadays, government subsidized slaughter is legally required, costing a few guilders per animal. Now organs, blood (sanger), (even at home slaughter) are all thrown away and buried on the landfill. "People on Bonaire have become too lazy to prepare these traditional products and dishes" [1].
On arrival at the slaughterhouse, all animals are inspected live: animals with syndromes suspected of being zoonoses (diseases that are transmitted from animals to human) can pose a risk to public health. The animal can become immediately rejected for slaughter, will be put to death and sent to Lagun for incineration, that is installed recently (Fig. 11, Table 17).

Figure 11 Incineration plant at Lagun (source: Han Soethoudt).

Table 17 Characteristics of the incineration plant Bonaire[17].

Topic	Data
Fuel type	Oil
Capacity	4,000 kg (6.75 m³)
Burn rate	1000 kg/h
Avg Ash residue	3%
Avg Fuel consumption per h per burner	25 L
Min. Operating Temperature	950 °C
Max. Operating Temperature	1500 °C

The products that are incinerated are considered as dangerous for health or society, such as animals with diseases or medical waste from the hospital.

Selibon has recycling parks in Kralendijk and Rincon. At Lagun there is a waste center. A new facility to store waste oil was built in 2022. The finished oil, including from garages, is temporarily saved until it is shipped to Curaçao where it is processed for asphalt. The collected glass is ground so that it can be used as filling for foundations. Metal and for example batteries go to Asia for re-use. Cardboard is also exported that way. Frying fat is collected and transported to the Netherlands for processing into biodiesel[18].

It can be concluded that recycling does not take place in Bonaire itself, but recycling initiatives are present.

[17] Source: mail 2022-08-09 from Selibon
[18] Source: mail 2022-08-09 from Selibon

8 Conclusions

The study at hand provides estimates of the volume of organic waste that is collected or relatively easy to collect by Selibon in one year. An overview is shown in Table 18.

Table 18 Summary of estimated annually available organic waste on Bonaire for composting and/or anaerobic digestion.

Type of waste		Waste flow (in tons as is)	Origin
GFT		183	Household waste
Paper and cardboard		613	Household waste
Wood		66	Household waste
Garden waste		3,572	Household and company waste
GFT waste		92	Company waste
Chicken manure		1,200	Farm Punta Blanku
Goat manure		2,000	Goats that are not free
Paper and cardboard		4,505	Restaurant
		1,842	Hotel/resort
		2,115	Supermarket/shop
Wood		637	Hotel/resort

Note that a lot of the organic waste is used for feeding animals. This means that the amount of organic waste collected by Selibon is relatively low when compared to the amount of organic waste in the streams collected in Netherlands. The use for animal feed may be considered more sustainable (higher preference on the valorization ladder of Moerman) than composting or anaerobic digestion which would be the alternative application if collected as waste. There may be an opportunity to make animal feed from manure with the help of the BSF, which is studied in another part of the project (Work package 3).
In addition, research is being conducted on the use of sargassum collected after or before it comes ashore, that will be reported separately (Work package 4).

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Annex 1: Import Bonaire 2020 (F&D)

	Product code	Belgium	Brazil	Estonia	Germany	Jamaica	NL	UK	Total	Cum gewicht%	Product description
1	220300						1723	580	2302	18%	Beer: made from malt
2	91091						1864		1864	32%	Spices: mixtures
3	230990						1843		1843	47%	Dog or cat food: (not put up for retail sale), used in animal feeding
4	20741		593				19		612	51%	Meat and edible offal: of fowls of the species gallus domesticus, poultry cuts and offal (excluding livers), frozen
5	220110	299					201	86	586	56%	Waters: mineral and aerated, including natural or artificial, (not containing added sugar or other sweetening matter nor flavoured)
6	110100	485					40		524	60%	Wheat or meslin flour
7	210690	0				5	447	16	468	64%	Food preparations: n.e.s. in item no. 2106.10
8	220210						333	41	374	66%	Waters: including mineral and aerated, containing added sugar or other sweetening matter or flavoured
9	200410						321		321	69%	Vegetable preparations: potatoes, prepared or preserved otherwise than by vinegar or acetic acid, frozen
10	70190						315		315	71%	Vegetables: potatoes (other than seed), fresh or chilled
11	230690						263		263	73%	Oil-cake and other solid residues: whether or not ground or in the form of pellets, resulting from the extraction of oils, n.e.s. in heading no. 2306
12	220830						3	203	206	75%	Whiskies
13	91099					0	183		183	76%	Spices: mixtures of 2 or more products of the same heading
14	230910		56				125		182	78%	Dog or cat food: put up for retail sale, used in animal feeding
15	40110						179		179	79%	Dairy produce: milk and cream, not concentrated, not containing added sugar or other sweetening matter, of a fat content not exceeding 1% (by weight)
16	200520						22	131	153	80%	Vegetable preparations: potatoes, prepared or preserved otherwise than by vinegar or acetic acid, not frozen
17	220421						134		134	81%	Wine: still, in containers holding 2 litres or less
18	210390					5	122	3	131	82%	Sauces and preparations therefor: mixed condiments and mixed seasonings
19	40120				67		63		129	83%	Dairy produce: milk and cream, not concentrated, not containing added sugar or other sweetening matter, of a fat content exceeding 1% but not exceeding 6% (by weight)
20	151219			92			37		128	84%	Vegetable oils: sunflower seed or safflower oil and their fractions, other than crude, whether or not refined, but not chemically modified
21	20329		112				1		113	85%	Meat: of swine, n.e.s. in item no. 0203.2, frozen
22	200490						112		112	86%	Vegetable preparations: vegetables and mixtures of vegetables (excluding potatoes), prepared or preserved otherwise than by vinegar or acetic acid, frozen
23	40690						106		106	87%	Dairy produce: cheese (not grated, powdered or processed), n.e.s. in heading no. 0406
24	71080						104		104	88%	Vegetables: uncooked or cooked by steaming or boiling in water, frozen, n.e.s. in chapter 7
25	160210						87		87	89%	Meat preparations: homogenised preparations of meat, meat offal or blood
26	200980					47	33		80	89%	Juice: of any single fruit or vegetable n.e.s. in heading no. 2009, unfermented, not containing added spirit, whether or not containing added sugar or other sweetening matter
27	200590						68		68	90%	Vegetable preparations: vegetables and mixtures of vegetables n.e.s. in heading no. 2005, prepared or preserved otherwise than by vinegar or acetic acid, not frozen
28	200990					22	40	1	63	90%	Juices: mixtures, unfermented, not containing added spirit, whether or not containing added sugar or other sweetening matter
29	20230		31				30		62	91%	Meat: of bovine animals, boneless cuts, frozen
30	121490						55		55	91%	Forage products including swedes, mangolds, fodder roots, hay, sainfoin, clover, forage kale, lupines, vetches etc., pelletised or otherwise

Annex 1 Running projects on Bonaire in relation to agriculture

In [21] projects related to agriculture are summarized:

• Green Bonaire horticultural project: vegetable greenhouses built on the grounds of the Krusada foundation. The Krusada's three greenhouses have a total surface area of 500 m^2. There will be different crops grown such as spinach, bok choy and arugula, and various herbs (basil, mint).
Previously, more different vegetables were grown and sold to individual customers. Recently focus is more on the hospitality industry on Bonaire. This is because it can purchase larger quantities and perhaps also guarantee a more secure purchase. Production cannot compete with the prices of imported products such as from Venezuela. That is why the focus has become on restaurants because they consider freshness more important than the individual consumer. The three greenhouses are currently running still partly on healthcare subsidy from the Krusada foundation. The plan for the future is vegetable cultivation without subsidies. Three clients of the Fundashon Krusada are currently working in the vegetable greenhouses. Because this happens on an irregular basis, they mainly perform free hand and span services. The Rotary on Bonaire has a project where children at school can have a healthy breakfast.

• POP project where the treated sewage from the sewage treatment plant is available to be distributed to interested farmers. That water gives the certainty every other year to produce around.

• The 'Mi Hofito' project of LVV of the Spatial Planning and Development Directorate in which households have a small greenhouse to grow vegetables themselves so that people at a household level become a little more self-sufficient. In Rincon, a few hundred people participated in the workshop. Seventy people currently have a greenhouse, of which fifty people have a greenhouse received from the project and twenty people built their own greenhouse. In Playa (Kralendijk) about 150 people participated. And in the context of the RDP, a manual how to grow fruit and vegetables at home on Bonaire was provided. The Ministry of Economic Affairs has financed 20 greenhouses for Antriol. In the context of POP, a hundred greenhouses for families who are dependent on the food bank, are available.

• In addition, the EZ RCN unit for LVV has purchased pedigree rams and bucks with which livestock farmers cover their sheep and goats. With this, LVV wants to improve the diversity and quality of the livestock (healthy livestock) on Bonaire.

• About 500 trees have been planted in the fruit trees project.

• Roald Boom of Bona Bista Island Estate currently fits two on a small scale agricultural techniques. Firstly, that is permanent agriculture where investments are made first in the soil quality and then development of an ecosystem that then continuously supplies agricultural crops. That project has been going on for three years. The second technique is hydroponics. That is a system in which vegetables grow directly in water with nutrients instead of in the ground. Roald Boom is organizing courses on hydroponics.

• Almost the entire supply of eggs on Bonaire is supplied by the chicken farm Punta Blanku. In addition, Punta Blanku has about 800 goats on its 350 hectare property. In 2013, a vegetable garden was created on the property by Punta Berde. On a small scale it is tried to grow organic vegetables in the open ground.

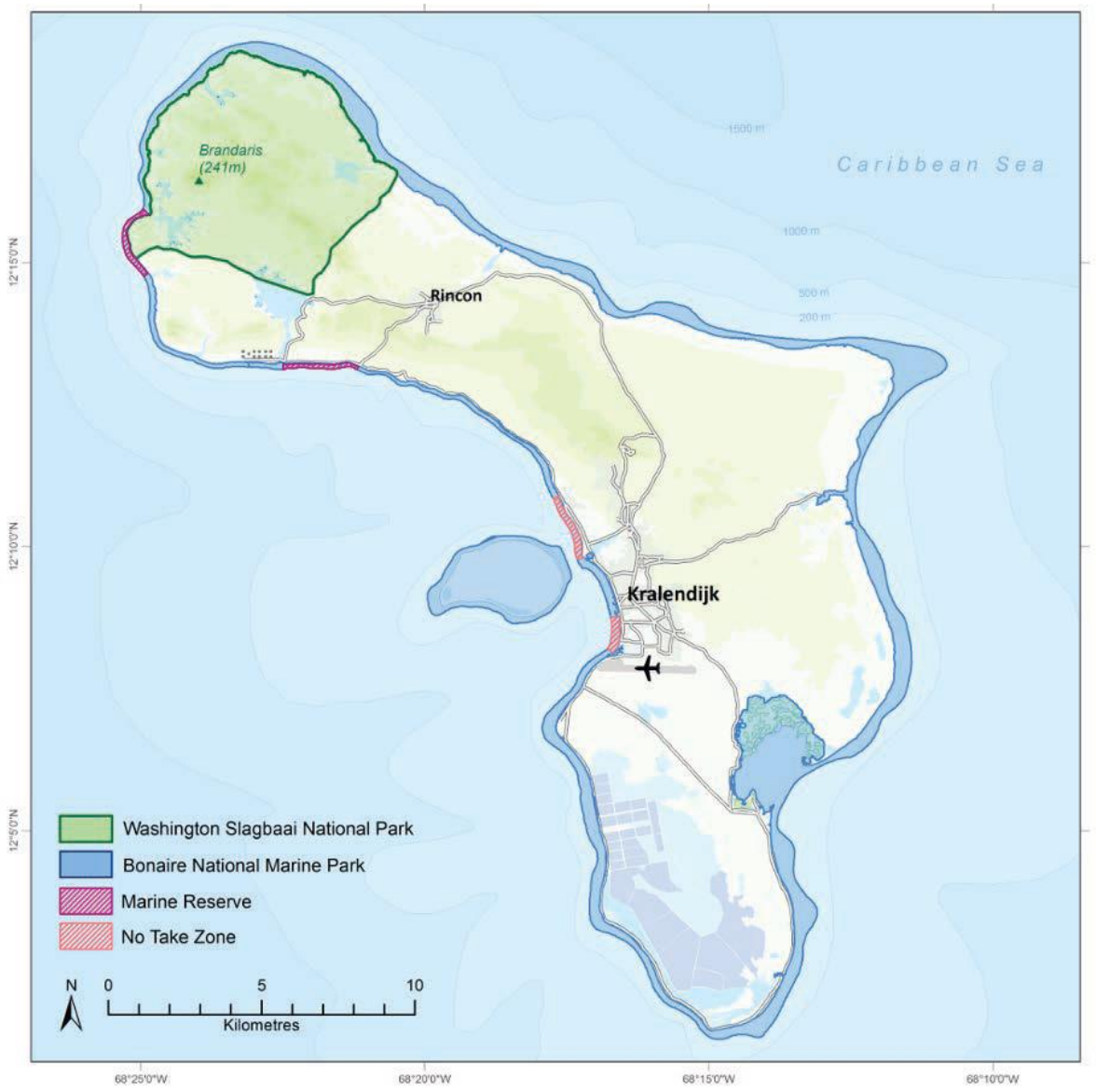
Annex 2 Input for interviews

In the table the interviewees from 3 projects on Bonaire are listed, including the project they were related to.

	Naam	Organisatie	project	jaar
1	Sherwin Pourier	Bonaire Agri & Aqua Business bv,	Bonaire 2050 - A nature inclusive vision	2020
2	Quirijn Coolen	BonBèrdè	Bonaire 2050 - A nature inclusive vision	2020
3	Ghislaine Monte	Chamber of commerce, 'blue destination'	Bonaire 2050 - A nature inclusive vision	2020
4	Tadzio Bervoets	Dutch Caribbean Nature Alliance	Bonaire 2050 - A nature inclusive vision	2020
5	Julianka Clarenda	ECHO Bonaire	Bonaire 2050 - A nature inclusive vision	2020
6	Frank van Slobbe	Openbaar Lichaam Bonaire – directie Ruimte en Ontwikkeling	Bonaire 2050 - A nature inclusive vision	2020
7	Danilo Christiaan	Mangazina di rei	Bonaire 2050 - A nature inclusive vision	2020
8	Kalli de Meyer	Nature 2	Bonaire 2050 - A nature inclusive vision	2020
9	Yoeri de Vries	Rijksdienst Caribisch Nederland, LNV	Bonaire 2050 - A nature inclusive vision	2020
10	Reynolds Oleana	Rijksdienst Caribisch Nederland, OCW	Bonaire 2050 - A nature inclusive vision	2020
11	Paul Hoetjes	retired, former Rijksdienst Caribisch Nederland LNV	Bonaire 2050 - A nature inclusive vision	2020
12	Esther Meijer-Sedney	Statistics Netherlands	Bonaire 2050 - A nature inclusive vision	2020
13	Henk van de Velden	Statistics Netherlands	Bonaire 2050 - A nature inclusive vision	2020
14	Paulo Bertuol	STINAPA	Bonaire 2050 - A nature inclusive vision	2020
15	Caren Eckrich	STINAPA	Bonaire 2050 - A nature inclusive vision	2020
16	Sabine Engel	STINAPA	Bonaire 2050 - A nature inclusive vision	2020
17	Roxanne-Liana Francisca	STINAPA	Bonaire 2050 - A nature inclusive vision	2020
18	Wijnand de Wolf	STINAPA	Bonaire 2050 - A nature inclusive vision	2020
19	Elsmarie Beukeboom	retired, former director of STINAPA	Bonaire 2050 - A nature inclusive vision	2020
20	Cristely Cranston	Tourism Corporation Bonaire	Bonaire 2050 - A nature inclusive vision	2020
21	Jan Jaap van Almenkerk	Wayaka advies	Bonaire 2050 - A nature inclusive vision	2020
		Projectleider POP Bonaire	Voedselzekerheid op Bonaire, St. Eustatius e	2015
22	Pieter van Baren	World Wide Fund for nature	Bonaire 2050 - A nature inclusive vision	2020
23	Jan Jaap van der Wel	Tuinbouwbedrijf Green Bonaire - tuinder	Voedselzekerheid op Bonaire, St. Eustatius e	2015
24	Pieter Groenendal	Tuinbouwbedrijf Green Bonaire - partner/investeerderinder	Voedselzekerheid op Bonaire, St. Eustatius e	2015
25	Vincente Figaroa	Interim directeur LVV va de irectie Ruimte en Ontwikkeling	Voedselzekerheid op Bonaire, St. Eustatius e	2015
26	Raymond Emers	werknemer LVV	Voedselzekerheid op Bonaire, St. Eustatius e	2015
27	Roald Boom	projectontwikkelaar Bona Bista Island Estate	Voedselzekerheid op Bonaire, St. Eustatius e	2015
28	Edwin Emerenciana	Manager kippenfarm Punta Blanka	Voedselzekerheid op Bonaire, St. Eustatius e	2015
29	Corien Unger	coördinator tuinbouw Punta Berde	Voedselzekerheid op Bonaire, St. Eustatius e	2015
30	Joris Karman	Directeur Scholengemeenschap Bonaire	Voedselzekerheid op Bonaire, St. Eustatius e	2015
31	Sharon Bol	Coördinator Boneiru Duradero	Voedselzekerheid op Bonaire, St. Eustatius e	2015
32	Arie Boers	Coördinator tuinbouw Fundashon Krusada	Voedselzekerheid op Bonaire, St. Eustatius e	2015
33	Dhr. Edison Rijna	OLB gezaghebber	Quick Scan - BONAIRE 202020	2014
34	Mevr. Nereida M. González	OLB Eilandsecretaris	Quick Scan - BONAIRE 202020	2014
35	Dhr. Edsel Winklaar	OLB gedeputeerde	Quick Scan - BONAIRE 202020	2014
36	Dhr. James Kroon	OLB gedeputeerde	Quick Scan - BONAIRE 202020	2014
37	Mevr. Rosa Hoes	OLB Directeur Samenleving en Zorg	Quick Scan - BONAIRE 202020	2014
38	Dhr. Jonathan Jukema	OLB Directeur Directie Ruimte en Ontwikkeling.	Quick Scan - BONAIRE 202020	2014
39	Dhr. Marco Gravenhorst	OLB beleidsmedewerker Directie Ruimte en Ontwikkeling	Quick Scan - BONAIRE 202020	2014
40	Dhr. Jan de Vries	OLB adviseur	Quick Scan - BONAIRE 202020	2014
41	Mevr. Marisela Croes	Voorzitter Kamer van Koophandel Bonaire	Quick Scan - BONAIRE 202020	2014
42	Dhr. Evert Piar	Bestuurslid Kamer van Koophandel Bonaire	Quick Scan - BONAIRE 202020	2014
43	Dhr. Dick ter Burg	Directeur Kamer van Koophandel Bonaire	Quick Scan - BONAIRE 202020	2014
44	Dhr. Mocky Arends	Voorzitter Bonaire Business and Employers Association	Quick Scan - BONAIRE 202020	2014
45	Dhr. John Soliano	Managing Director Bonaire Holding Maatschappij	Quick Scan - BONAIRE 202020	2014
46	Dhr. Jan Kloos	President Commissaris Bonaire International Airport N.V.	Quick Scan - BONAIRE 202020	2014
47	Dhr. Elvis Tjin Asjoe	MDP	Quick Scan - BONAIRE 202020	2014
48	Dhr. Robby Beukeboom	DP partij	Quick Scan - BONAIRE 202020	2014
49	Dhr. Ramonsito Booi	Eilandsraadslid UPB	Quick Scan - BONAIRE 202020	2014
50	Mevr. Irene Dingjan	CEO Bonaire Hotel and Tourism Association	Quick Scan - BONAIRE 202020	2014
51	Dhr. Patrice Rannou	Voorzitter Bonaire Restaurant Association	Quick Scan - BONAIRE 202020	2014
52	Dhr. Johan Afman	Interim Director Stinapa	Quick Scan - BONAIRE 202020	2014
53	Dhr. Leonard Domacasse	Directeur Maduro & Curiel Bank	Quick Scan - BONAIRE 202020	2014
54	Dhr. Patrick Dowling	General Manager Flamengo Television	Quick Scan - BONAIRE 202020	2014
55	Dhr. Larry Gerharts	General Manager Bonaire Air Services	Quick Scan - BONAIRE 202020	2014
56	Dhr. Ben Swagerman	Senior Vice President KLM Security Services	Quick Scan - BONAIRE 202020	2014
57	Dhr. Max Smits	General Manager Air France/KLM Dutch Caribbean	Quick Scan - BONAIRE 202020	2014
58	Dhr. Tom Peeters	Advocaat VanEps Kunneman VanDoorne	Quick Scan - BONAIRE 202020	2014
59	Dhr. Jan Ebbing	Managing Director TNO Caribbean Branch Office	Quick Scan - BONAIRE 202020	2014
60	Dhr. Gerard van den Tweel	ondernemer	Quick Scan - BONAIRE 202020	2014
61	Dhr. Kees de Mooij	ondernemer	Quick Scan - BONAIRE 202020	2014
62	Dhr. Jaap Rutger Kos	KPMG Caribbean Bonaire	Quick Scan - BONAIRE 202020	2014
63	Dhr. Pieter Groenendaal	ondernemer	Quick Scan - BONAIRE 202020	2014
64	Dhr. Huub Groot	ondernemer	Quick Scan - BONAIRE 202020	2014
65	Mevr. Esther Wolfs	WKICS/Wolfs	Quick Scan - BONAIRE 202020	2014
66	Dhr. Huib de Bliek	Hoofd Eenheid Economische Zaken Rijksdienst Caribisch Nederland	Quick Scan - BONAIRE 202020	2014
67	Dhr. Albert Salman	director Global Sustainable Tourism Review GSTR - Green Destinati	Quick Scan - BONAIRE 202020	2014
68	Dhr. Martien van der Valk	Directeur Sapias Holding N.V.	Quick Scan - BONAIRE 202020	2014
69	Dhr Rob Oostendorp	hoofd product Cariben bij TUI Nederland	Quick Scan - BONAIRE 202020	2014
70	Mevr. Candice Kimmel	Adams PR - TCB Marketing VS	Quick Scan - BONAIRE 202020	2014
71	Dhr Eugène Westerink	directeur Cruise Travel Nederland	Quick Scan - BONAIRE 202020	2014
72	Mevr. Ellen Schulten	senior lecturer hospitality Business bij Saxion Hogeschool	Quick Scan - BONAIRE 202020	2014
73	Dhr. William Cline	board member Diving Equipment & Marketing Association	Quick Scan - BONAIRE 202020	2014
74	Mevr Yasmin Perez	Flamingo Representaciones - TCB marketing Zuid Amerika	Quick Scan - BONAIRE 202020	2014
75	Dhr. Roger Davids	BASIS Communicatie - TCB marketing Nederland	Quick Scan - BONAIRE 202020	2014
76	Dhr. Boudewijn Scholts	Bonhata	Quick Scan - BONAIRE 202020	2014
77	Dhr. Roger Jurriens	eigenaar Boutique Hotel Sonrisa/ The windsurfplace39	Quick Scan - BONAIRE 202020	2014
78	Dhr. Roan Jasparse	Kite boarding Bonaire	Quick Scan - BONAIRE 202020	2014
79	Dhr. Freek Hoving	Kite boarding Bonaire	Quick Scan - BONAIRE 202020	2014
80	Dhr. Hans Voerman	Outdoor Bonaire en Ecolodge Bonaire	Quick Scan - BONAIRE 202020	2014
81	Dhr. Charles Vos	GM Divi Flamingo	Quick Scan - BONAIRE 202020	2014
82	Dhr. Gaby Tixi	Cruise manager TCB	Quick Scan - BONAIRE 202020	2014
83	Dhr. Muys Cieremans	bestuurslid BHG	Quick Scan - BONAIRE 202020	2014
84	Dhr. Pascal de Meyer	GM Dive Friends Bonaire	Quick Scan - BONAIRE 202020	2014
85	Mevr. Imke Carsouw	Directievoorzitter Blueport Development	Quick Scan - BONAIRE 202020	2014

Annex 3 Maps of Bonaire

Map 4.1: Map of Bonaire indicating the Bonaire National Marine Park area, Marine Reserve and No Take Zone's [14].



Map 4.2: Landscape map of Bonaire. Each type delineates an area with coherent biophysical, cultural and aesthetic characteristics [22].

Map 4.3: Groundwater salinity in 2016 [22].

Annex 4 Climate of Bonaire

Climate figures are shown in the table below: Source: https://klimaatinfo.nl/klimaat/bonaire/
Other source: https://klimaatinfo.nl/klimaat/bonaire/

Annually, Bonaire has about 350 to 450 millimetres of precipitation always in the form of rain.

Klimaatcijfers

Onderstaande cijfers zijn gebaseerd op langjarige gemiddelde klimaatstatistieken. De temperaturen worden weergegeven in graden Celsius (°C).

	maximum temperatuur	minimum temperatuur	uren zonneschijn per dag	dagen neerslag per maand	hoeveelheid neerslag per maand	water temperatuur
januari	30°C	24°C	8	9	💧💧	26°C
februari	30°C	24°C	9	4	💧	25°C
maart	30°C	25°C	9	3	💧	26°C
april	30°C	25°C	8	2	💧	26°C
mei	31°C	26°C	8	2	💧	27°C
juni	31°C	26°C	8	3	💧	27°C
juli	31°C	26°C	9	6	💧💧	27°C
augustus	32°C	27°C	9	4	💧💧	28°C
september	32°C	27°C	8	5	💧💧	28°C
oktober	32°C	26°C	8	8	💧💧💧	28°C
november	31°C	26°C	8	12	💧💧💧	28°C
december	30°C	25°C	8	11	💧💧💧	27°C

0-5 mm = NIHIL | 6-30 mm = 💧 | 31-60 mm = 💧💧 | 61-100 mm = 💧💧💧 | 101-200 mm = 💧💧💧💧 | meer dan 200 mm = 💧💧💧💧💧

Annex 5 Set up of the measurement

The experiment was designed by WUR and executed by Melinda Marchena (Selibon) and Christle Nieuw (student WUR).

Goal:
The goal was to analyse the household and company waste, that is collected by Selibon, in more detail. This way valorisation options can be targeted in a better way, provided the volumes are large enough. The categories for separation were:

1. Starch products
2. Meat and Fish
3. Bread
4. Dairy products
5. Sauces
6. DKW
7. Misc.
8. Garden waste
9. Other (non-food)

Planning:
The measurements took place in one week in May 2023. On Tuesday and Wednesday household waste was analysed, on Thursday and Friday company waste, all according to the scheme below:

Table 19 Planning of waste measurements.

Date	District	Description
Tuesday 9/5/2023	Playa Pariba	Low-rise, spacious with many holiday homes and offices
Wednesday 10/05/2023	Nikiboko Zuid	Low-rise, spacious with many holiday homes and only few offices
Thursday 11/05/2023	Company route	Various shops, offices, hotels, restaurants and bars
Friday 12/05/2023	Company route	Various shops, offices, hotels, restaurants and bars and garbage bins on public locations and beaches

Procedure:
The general routine started with weighing the empty pick-up truck and then to collect four empty garbage bins of 240 litres. These garbage bins are transported to the landfill where a location is designated for the garbage truck to drop its contents. After the contents of the garbage truck are dropped, an excavator (if available) evens out the pile of waste and randomly scoops waste to transport near the garbage bins for placement. If an excavator is not available, waste would be picked from the pile manually and placed in the garbage bins. Once all four garbage bins are filled with waste, they are placed back in the pick-up truck to be transported to the scale to be weighed. Then, the garbage bins are returned to the designated location and its contents are emptied nearby. All containers and packaging such as trash bags and boxes were then opened and emptied to start the process of sifting through and separating the waste according to the nine categories above (see Figure 13 for procedures).
A picture is taken of each specific pile and then stored in separate bags (Figure). The final steps are taking the bags with categorized waste to be weighed, and thrown back away.

Figure 12 Pictures of the organic waste share (source: Melinda Marchena/Christle Nieuw).

A designated location was set where the garbage trucks would unload the household waste. The circled area is where the waste is to be placed.

After the waste was dumped

The excavator spread the waste evenly, then randomly picked up the waste that was guided into the four garbage bins until they were each full

On this day, the vehicle without waste weighs 2080 KG. The vehicle including the abovementioned klikos (4 x 240 litres filled with household waste) weighs 2220 KG. Pictured is vehicle being weighed at the scale of the Selibon landfill.

We started the process of breaking all of the plastic bags apart, opening boxes or anything that may contain other items from the waste collected.

The organic waste we managed to find was not much, as seen below, the red contains fruits and vegetables, the blue was meat (specifically chicken), and the yellow is bread

Figure 13 Pictures from the measurement (source: Melinda Marchena/Christle Nieuw).

Annex 6 Organic production data

Year of source	Production information	products	organization
2004-2011	88 ha	Horticultural products	Farmers on Kunukus
2014	4 ha	Sucro Sorghum	?
?	500 m^2 greenhouse	Vegetables	Krusada Foundation
2019	7250 m^2 greenhouse; 140-160 bags of spinach per week, equal to 7500 per year	Spinach, cherry tomato, snack cucumber, long beans, mint	Bon Tera
2019	500 m^2 greenhouse; 800 heads of 175 gr average equals 7 tons per year	Lettuce	Bon Tera
2020	1250 m^2 greenhouse; 120,000 pieces of vegetables per year	Lettuce, cabbage, spinach, bok choy, garlic	DailyFresh
?	27,000 hens laying eggs	Eggs	Punta Blanku
?	3,000 hens	?	Poultry farm in Rincon
2012-2018	4 cattle slaughters	cattle	Slaughterhouse
	132 pig slaughters; 4182 kg average per year	pig	
	295 sheep slaughters; 4720 kg average per year	Sheep	
	1509 goat slaughters; 15,735 kg average per year	goat	
2014	103 tons	Red snapper (23%), fish/piska (not specified) (14%), tuna (14%), mahi mahi (14%) and barracuda (14%)	30-40 fishermen
?	25,000-35,000 dm kg per year as feed	Grass Brachiaria Mulato II	

Wageningen Food & Biobased Research
Bornse Weilanden 9
6708 WG Wageningen
The Netherlands
E info.wfbr@wur.nl
wur.eu/wfbr

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