# A nature inclusive vision for Bonaire in 2050

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Reviewed by:
Jeanne Nel, senior researcher (Wageningen Environmental Research)

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Sander Janssen, team leader of Earth Observation and Environmental Informatics

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In collaboration with:
Sherwin Pourier (Bonaire Agri & Aqua Business bv)
Quirijn Coolen (BonBèrdè)
Ghislaine Monte (Chamber of commerce, 'blue destination')
Tadzio Bervoets (Dutch Caribbean Nature Alliance)
Julianka Clarenda (ECHO Bonaire)
Frank van Slobbe (Openbaar Lichaam Bonaire – directie Ruimte en Ontwikkeling)
Danilo Christiaan (Mangazina di rei)
Kalli de Meyer (Nature2)
Yoeri de Vries, Reynolds Oleana (Rijksdienst Caribisch Nederland, resp. LNV and OCW)
Paul Hoetjes (retired, former Rijksdienst Caribisch Nederland LNV)
Esther Meijer-Sedney, Henk van de Velden (Statistics Netherlands)
Paulo Bertuol, Caren Eckrich, Sabine Engel, Roxanne-Liana Francisca, Wijnand de Wolf (STINAPA)
Elsmarie Beukeboom (retired, former director of STINAPA)
Cristely Cranston (Tourism Corporation Bonaire)
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name: Jeanne Nel

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# 1 Why this study?

Bonaire, one of the Dutch Caribbean islands, is facing major challenges: managing (mass) tourism and population growth, preventing high erosion rates due to free-roaming cattle, recharging fresh water into the soil, increasing the use of renewable energy, adaptation to sea level rise and extreme weather events, halting biodiversity loss and tackling the unilateral dependency on tourism. In thirty years, Bonaire inevitably will look different. Progressing on current trends will only increase the challenges, a new way of thinking, planning and acting is needed.

A new story for Bonaire is needed. A story that addresses these challenges. A story that can be shaped by citizens of Bonaire, and which can grow this small developing island into an example that aligns well-being and prosperity with cultural heritage, and embraces the protection of nature for our livelihoods.

Together with local experts a vision for Bonaire in 2050 is portrayed, in which nature and natural processes play a key role in all development activities – a 'nature inclusive vision'. The vision aims to inspire. It outlines a future in which economic development and a nature inclusive society join forces to maintain what is precious, and to improve what is already impaired or threatened.

These images of the future are based on results from a series of design sessions, interviews and workshops with local experts and researchers, which culminated in an interactive session that brought together the knowledge of island experts and decision-makers from nature, agriculture, recreation, culture and government. Participants collectively mapped out potential nature-inclusive measures and deliberated where, why and how these could be adopted. These potential measures include for example rooftop water harvesting, reforestation and greening gardens using indigenous species, coral restoration, growing local food, cactus fences and solar roofs. The vision considers the characteristics and cultural contexts of the different landscapes of Bonaire, builds on the local history of planning and links into ongoing Bonairean and Dutch visions and strategies.

The report starts by describing the policy context and challenges. It then looks at what nature inclusive concepts can offer to navigate some of the challenges Bonaire is experiencing illustrated by three-dimensional landscape visualisations.

# 2 Previously on Bonaire: a policy background

For an overview of important developments in policy we go back to the early 1990s when economic development in Bonaire gained momentum (Figure 1). This resulted in work surplus especially in tourism services, and an influx of foreign workers. While tourism brought prosperity to the island, it also brought problems, such as nature degradation, increased crime and use of narcotics, and an increase in food and property prices. Lifestyle and culture of Bonairean people were suddenly under heavy pressure. These developments demanded for a policy framework to guide emerging local problems and external investments which was launched in 1992 as an integrated socio-economic strategy[1]. This strategy stated that the unique environmental values of Bonaire are the basis for further socio-economic development and imposed restrictions on all other activities, including tourism which compromised this. In particular, this required that Bonaire would refrain from promoting mass tourism, and limit the growth in population, hotel rooms and dive tourism. The Bonaire development plan (1998-2002) followed the 1992 integrated socio-economic strategy, but allowed growth of the tourism sector on the basis of high quality tourism with high added value for the local economy in terms of employment, income and balance of payments.

In 1999, a specific nature policy plan was developed for the period of 1999-2004, and provided an overview of the nature diversity on Bonaire[2]. This plan was motivated by the observation of internationally acknowledged unique nature values, and the threat of degradation by economic activities. Threats included habitat destruction from expanding urban areas and road construction, and contamination of soil and water.

It took more than 10 years before three important follow-up policy plans were introduced. The publication of these plans coincided with Bonaire becoming a special municipality of the Netherlands in 2010. All three plans paved the way for economic development in a sustainable way. Besides being a policy document, the Spatial development plan of Bonaire [3] became a legal instrument o to regulate where certain development activities could occur and where they were prohibited. The second policy document was a master plan; a vision document for the future (2010-2025) focusing on improving human well-being in terms of solidarity, cultural identity and prosperity[4]. The third document was a policy document on culture and cultural development as result of the by immigration driven population growth. This growth influences the authentic character and identity of Bonaire[5].

In 2013 a new national nature policy plan was published covering all islands of the Caribbean Netherlands, including Saba, St. Eustatius and Bonaire[6]. The Plan's objective is to ensure that nature on the Caribbean islands is used in a sustainable way to protect the island's ecosystems and ecosystem services. It was designed as a key instrument to promote socio-economic and human wellbeing and encourage the integration of nature conservation in the various public and socio-economic sectors, hence mainstreaming nature conservation into society.

The local government launched a vision on agriculture, husbandry and fisheries in 2014 [7]. The vision focuses on food production for Bonaireans, good production conditions for small scale farmers, a vital and appealing rural countryside and protection of nature and the environment. The vision has resulted in the rural development program (POP) running from 2014-2018. A total of forty projects have been carried out under this program within four main categories: a knowledge center, sustainable goat husbandry, rural tourism development and strengthening of entrepreneurship[8].

In 2017, the Tourism Corporation Bonaire in cooperation with a US hospitality management university, launched a plan, in which Bonaire was positioned as a 'Blue Destination' where ocean resources are used for growth, well-being, jobs, and ocean ecosystem health[9]. In contrast to any other previous plan it was stated that mass tourism and sustainable growth can be combined without causing bottlenecks. In this plan, nature is used as a marketing strategy for sustainable tourism and the multinational tourism industry. The plan proposes to ban toxic sunscreens and plastic bags, potentially reaping positive PR and promotions for Bonaire on an international market platform.

In 2020 an updated Nature Plan for Bonaire 2020-2024 was passed by the island council[10] and a national nature and environmental policy plan for 2020-2030 was published[11]. Currently a masterplan towards 2030 is being developed[12].

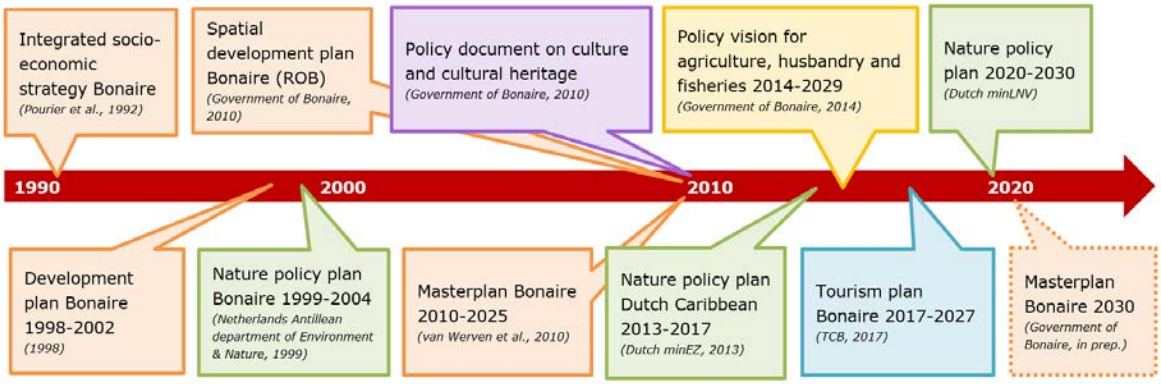



***Figure 1*** *An overview of main influential policy plans and documents to developments on Bonaire (orange – integrated development specific; green – nature specific; purple –culture specific; yellow – agriculture and fisheries specific and; blue – economic specific)*

# 3 Nature inclusive planning: a new way of doing

Approaches to interweave nature in sectors of society and economy span diverse terminologies and practices – nature inclusiveness, nature-based solutions, mainstreaming, ecosystem-based approaches, natural capital – the list goes on. These approaches respond to the challenge that nature goals are often reflected poorly in public and private sector policy and decision-making processes. The many different approaches attempt to work – in one way or another – beyond just the nature sector to highlight the contribution of nature to other sectoral goals and to leverage co-benefits that bridge social and economic interests. Joint consideration of achieving all outcomes can also highlight challenges and conflicts, and this explicit acknowledgement means that they can be negotiated in a more equitable and inclusive manner.

The notion of interweaving nature in all sectors is central to the Dutch concept "Nature inclusive", which finds its origin in policy documents "Natuurlijk kapitaal" and the "Rijksnatuurvisie" respectively written in 2013 and 2014. The concept "Nature inclusive" was originally defined as "nature included" which should be understood as *"a way of thinking and acting in which nature is always part (of the process)*" (EZ, 2014). At an institutional level, this concept emphasizes the embedding of nature considerations into a range of cross-sectoral planning processes, policies, standards and regulations, but also into general awareness and even informal office culture and processes. In planning for development, e.g. infrastructural designs, and other societal functions, this means considering nature up front, not compensating later for any detrimental effects.

The nature inclusive concept has evolved in various sectors in which the agricultural sector[13] and the urban sector (built environment) show the most progress in recent years. While exact approaches may differ, there are some common emerging characteristics:

- Nature inclusive concepts shift the emphasis from focusing solely on nature, to a focus on people AND nature as inextricably linked systems. Nature inclusive is about the integration and improvement of nature (habitats, species, biodiversity) Within OTHER sectors such as agriculture, urbanization, infrastructure and energy. It is about working with nature and improving it for goals other than only nature conservation.
- Nature inclusive concepts increase alignment between nature conservation and sustainable development objectives. They aim to address societal and economic challenges while simultaneously providing benefits to nature, and actively seek dual, positive biodiversity and development outcomes.
- Nature inclusive concepts acknowledge the trade-offs between different development goals, as well as current and future benefits. For example, degrading natural ecosystems can increase the vulnerability of people to climate change and other external shocks and reduce their options for development. Likewise, ill-planned conservation measures can exclude people from resources such as land and fisheries, or achieving food security can mean sacrificing conservation targets such as maintaining forests. There can also be trade-offs between the production of a few immediate economic benefits for development, and future options for the production of the full range of ecosystem services. Nature inclusive planning provides a fair and transparent process for negotiating such trade-offs. This requires iterative and meaningful involvement of stakeholders.
- Nature inclusive acting works best if there are genuine links to context-specific development objectives, taking account of natural and cultural contexts that include traditional, local and scientific knowledge. This requires iterative and meaningful involvement of stakeholders.
- Nature inclusive planning is usually best applied at a landscape scale. Even for a specific site level, it is important to consider this landscape-scale context and consequences across different sectors, aiming at upscaling where appropriate.
- Nature inclusive actions complement traditional nature conservation actions (e.g. protected areas), and are not a substitute.
- Nature-inclusive does not imply that all nature should be exploited up to maximum thresholds.

The type of nature inclusive approach adopted is context dependent, which is perhaps best characterized along gradients such as the level of human modification of the ecosystem, and the number of ecosystem services desired. Each may require different measures, but need to benefit both ecosystem and its services. Nature-inclusive is broader than the concepts of Building with Nature or Nature Based Solutions in that it requires consideration of multiple sectoral interests and the trade-offs and synergies among them. It also requires that in addressing societal challenges, positive outcomes for both nature and people are achieved.

# 4 Bonaire's challenges

As a small tropical island, Bonaire is rich in biodiversity and hosts a wide variety of globally threatened ecosystems[45]. These ecosystems are important for coastal protection and tourism, as well as for erosion control and resilience to climate change. At the same time, there are many different pressures that combine on this small area to impact both nature and other forms of land use. These include a rapidly growing population and tourism industry, expansion of the built environment, erosion, salt water intrusion and climate change, the latter resulting in sea-level rise and more frequent storm events[45]. The following paragraphs describe the challenges that Bonaire is facing in more details.

## 4.1 Urban and elite estate expansion

Urban growth is the gradual expansion of intensively inhabited areas, due to population growth and changes in the life pattern of the population. It is predominantly the process by which towns and cities are formed and become larger, as more people begin living and working in urban areas. In general, the food supply is therefore provided by an increasingly smaller part of the population, which increases the vulnerability of the food sector.

Early inhabitants of Bonaire were the Arawak descendant Caiquetio Indians that reached the island from Venezuela around 500 AD. A millennium later the Spaniards invaded Bonaire, bringing goats and donkeys, and started Rincon as the first settlement of Bonaire. Rincon was strategically chosen as it is nestled within a valley with natural water sources, fertile lands, hidden from potential invaders and has easy access to a lookout for spotting impending danger from pirates. Over the following decades several other settlements developed (e.g. Antriol). Early in the 17$^{th}$ century the Dutch invaded Bonaire in search of salt to preserve food, and started building fortifications on what is now known as the centre of Kralendijk. More settlements developed (e.g. Nikiboko, Noord Saliña and Tera Cora) and fisherman built their homes along the coast. Until a century ago, the inhabitants of Bonaire were mostly self-sufficient in their demand for food. From their homes in the settlements, they tended small plots of land, known as kunukus, to grow crops and to keep goats. In the 1960's, with the emergence of the oil industry in Venezuela, Aruba and Curaçao, and the growing banking and tourism sector, people left their kunukus to take on less physically demanding jobs in the urban area and abroad. With this, they were able to earn enough money to buy imported, non-local food from the supermarket. The kunukus became less important and many were abandoned or left fallow. As most Kunuku's were owned by large families, the kunukus got parceled up amongst heirs. More recently, kunuku owners sell their unused and relatively small kunukus to foreigners. [14, 15, 16, 17]

In 1961 Bonaire had a population of 5800, which tripled to 15.000 in 2010. After Bonaire became a special Dutch municipality in 2010, the population increased to 20.000 in ten years' time, mainly due to immigration (Figure 2). Population growth mostly takes place in urban areas. Over these decades the original settlements, except more remote Rincon, conglomerated into present Kralendijk[30, 18]. Figure 3 illustrates the expansion of the Kralendijk area. Recently, plans for housing development have been proposed on the distant unspoiled east coast of Bonaire ('Bolivia'), although these have not yet been approved by government and remain highly contentious among the local residents.[19, 20]

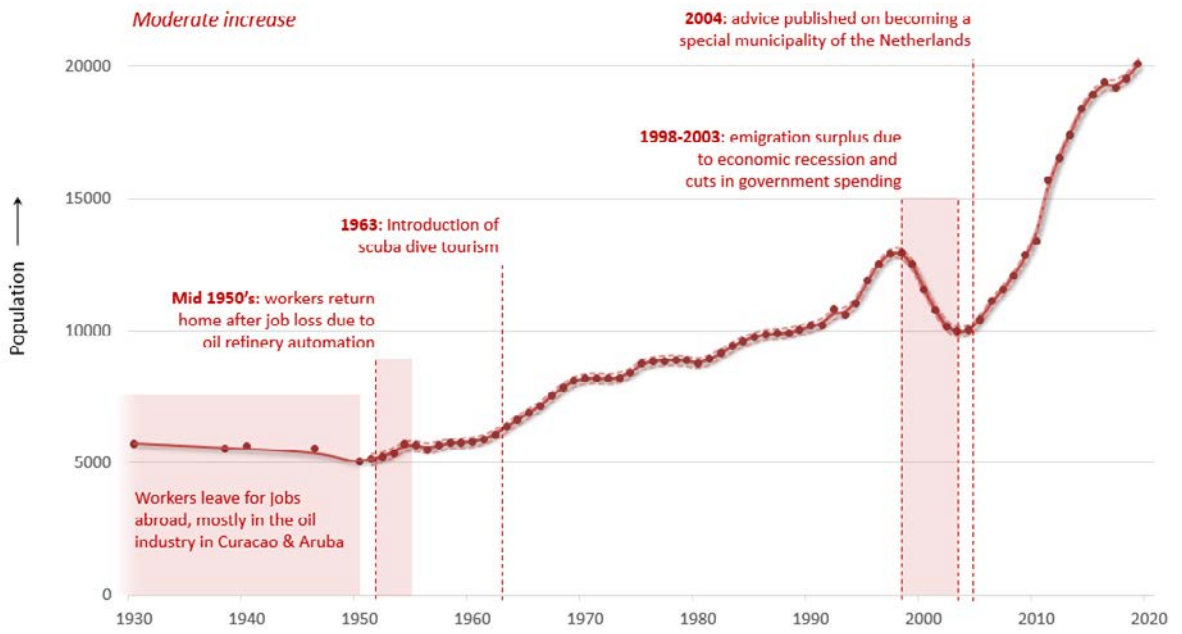



***Figure 2*** *Trend line of Bonaire's population[30, 18] which statistically shows a moderate increase[21, 1]*

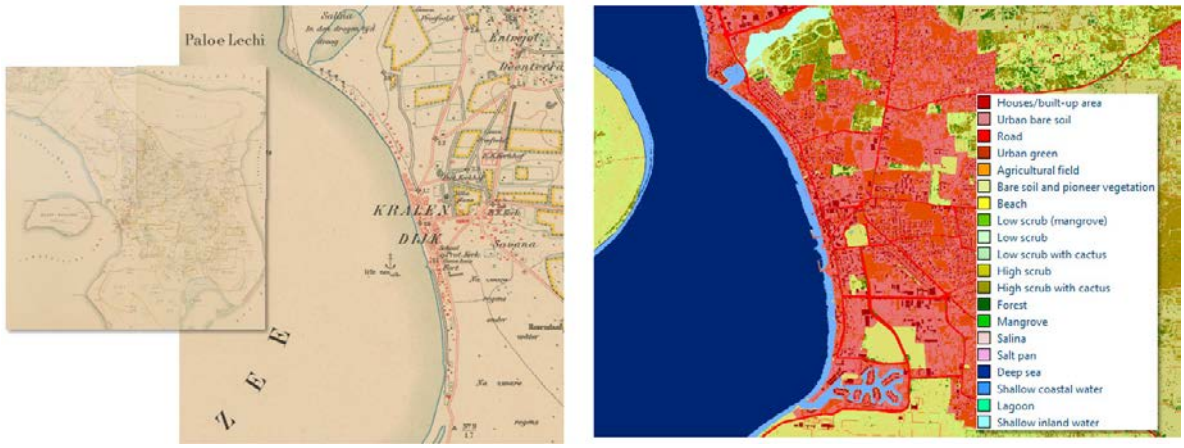



***Figure 3*** *Expansion of built environment of Kralendijk illustrated by two maps of the same area for two timeslots. In both images the built environment is shown in red. The left image shows an excerpt of the 1911 topographical map[22]. The right image shows a preliminary land use map interpreted from satellite imagery at 2x2 m2 resolution[23]*

## 4.2 A changing climate

The climate is the average weather (temperature, moisture, air pressure, wind, cloud and precipitation) over a certain period of time. The climate is not stable and changes as a result of natural and human influences. Over the past four decades the Earth's surface has become increasingly warmer, with ocean temperature increase making up 90% of the total global warming. Over the last century, the average sea level has also risen by 19 cm[24].

The Caribbean climate can be characterised as a tropical climate with alternating dry and wet seasons. In contrast to most of the Caribbean region, Bonaire has a dry tropical climate, although rain-carrying hurricanes generate sufficient water on the island to sustain semi-arid ecosystems. A conservative regional scenario projects 1.4 degrees Celsius average temperature rise, 5% less precipitation and 0.6 meter sea level rise[24]. Recent projections point to more severe impacts, particularly from more frequent extreme events associated with sea storms and drought (Figure 4). Climate change is

expected to impact both the natural and socio-economic situation on Bonaire. For example, the lower lying and coastal areas that host many of the resorts, residential areas, salt ponds, mangroves and (turtle nesting) beaches are likely to become subjected to more frequent damage from sea storms, and sea level rise will cause permanent flooding. In addition, sea water temperature rise is already weakening corals' resistance against diseases making these reefs less attractive for dive tourism. The decrease in precipitation will further limit growth of natural vegetation, increasing the risk for soil erosion, which is flushed to sea and smothers the coral, thus exacerbating the situation.[25]

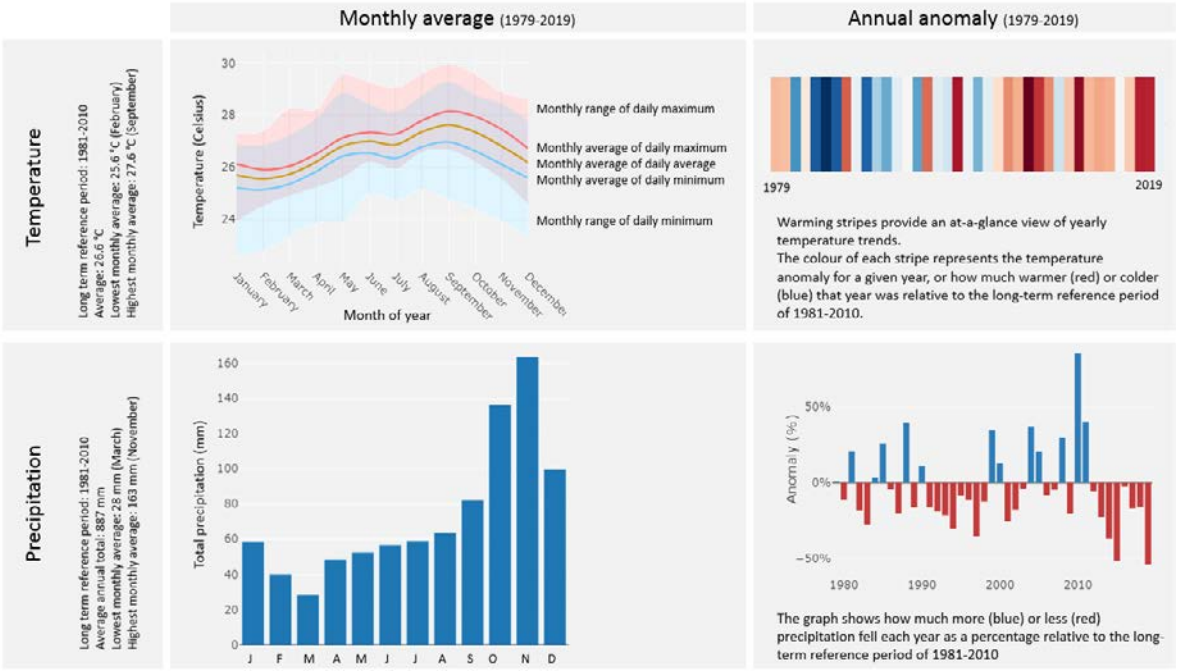



***Figure 4*** *Climate averages and anomalies of Bonaire*[26]

## 4.3 Diversifying the economy

Bonaire's economy relies largely on tourism[27], with about 500 thousand cruise[28, 29] and stay-over tourists a year on a population of 20 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%)[30]. This dependency on tourism makes the island's economy vulnerable to fluctuations on the market, global health issues and extreme weather events, as the current COVID19 crisis which has completely shut down all tourism related activities, has clearly demonstrated. The island would therefore benefit from a more diversified economy, in which a diversity of sectors contribute more evenly to the economy and spread the risk of slumps in one particular sector. Diversification could take place through stimulating the further development of financial and IT services (requiring stable and high speed internet facilities), bio-pharmaceutical industries (algae and aloe), increased local vegetable and fruit production, and goat meat and brine shrimp (live food for fish) production. Such bio-pharmaceutics and agricultural products can enhance export both within the Caribbean region as well as trade-centre and transit ports, e.g. between Europe and Latin America

## 4.4 Managing tourism

Already in 1976, the numbers of annual tourists exceeded the island population size (Figure 6). Since then, the numbers of tourists has grown exponentially, and today the annual tourist numbers exceed the local population size by a factor of 25. For comparison, for the Netherlands this factor is 1 for 2017 (a population of 17.2[31] million and a total of 17.6 million foreign tourists[32]). Two third of all tourists visiting the island annually are cruise tourists[28, 29]. Cruise tourism is a form of leisure travelling that involves an all-inclusive holiday on a cruise ship. Cruise tourism in Bonaire grew steadily in the 1990s and early 2000s, and started growing exponentially in the mid-2000s (Figure 5). In 2006 cruise ship tourism overtook the annual number of stay-over tourists. Cruise tourist visits are concentrated in a few months a year, between October and April. Typically these tourists stay on the island for a few hours during which they wander through town of Kralendijk, visit beaches or drive around the island in tour buses, mini-vans, taxis, golf-carts, quadbikes and motor cycles[33]. Road congestion occurs during disembarking and embarking. Off-road use of quads and motor cycles have additional social and environmental impacts, such as traffic dangers, the uncontrolled creation of new roads as well as disturbance of residents and nature[34]. Cruise tourists make little use of local hospitality services as cruise lines offer all-inclusive arrangements.

Stay-over tourists mainly visit the island for diving. The number of tourists has increased (Figure 5) substantially since 2010 when Bonaire became a special municipality of the Netherlands, but it still remains a small fraction of the number of annual tourists when compared with cruise tourism,

Increased tourism puts pressure on built infrastructure, especially at the west coast north and south of Kralendijk, and popular locations, such as the Lac Bay protected nature area which is increasingly being used for sunbathing and surfing (Figure 6, right map). Discussions to relieve the pressure on these hotspots have identified several potential alternatives for expanding the range of tourist activities, such as hiking, mountain biking and driving routes through the rural areas, mangrove kayaking, caving, museums with local culture and local cuisine. The number of tourists could also be limited by setting a (daily) maximum, possibly differentiated by location, as practiced in e.g. several National Parks elsewhere in the world. These potential alternatives could offer potential resilience within the tourism sector, diversifying the tourist attractions on Bonaire and offering a broader 'Blue and Green Destination' narrative. However, they also may increase the pressures on other relative undisturbed communities and sensitive ecosystems on the island.

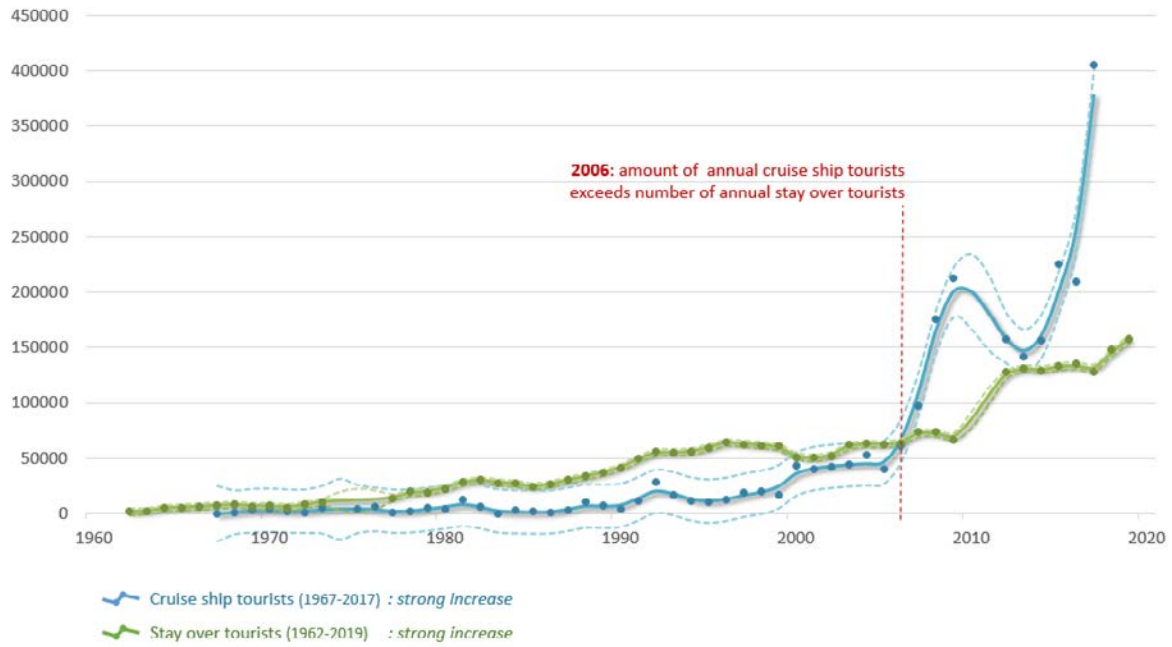



***Figure 5*** *Trend lines of tourists visiting Bonaire differentiated by cruise ship tourists and stay over tourists[30, 18]. Both cruise ship and stay over tourism growth can statistically be characterised 'strong increase'[35].*

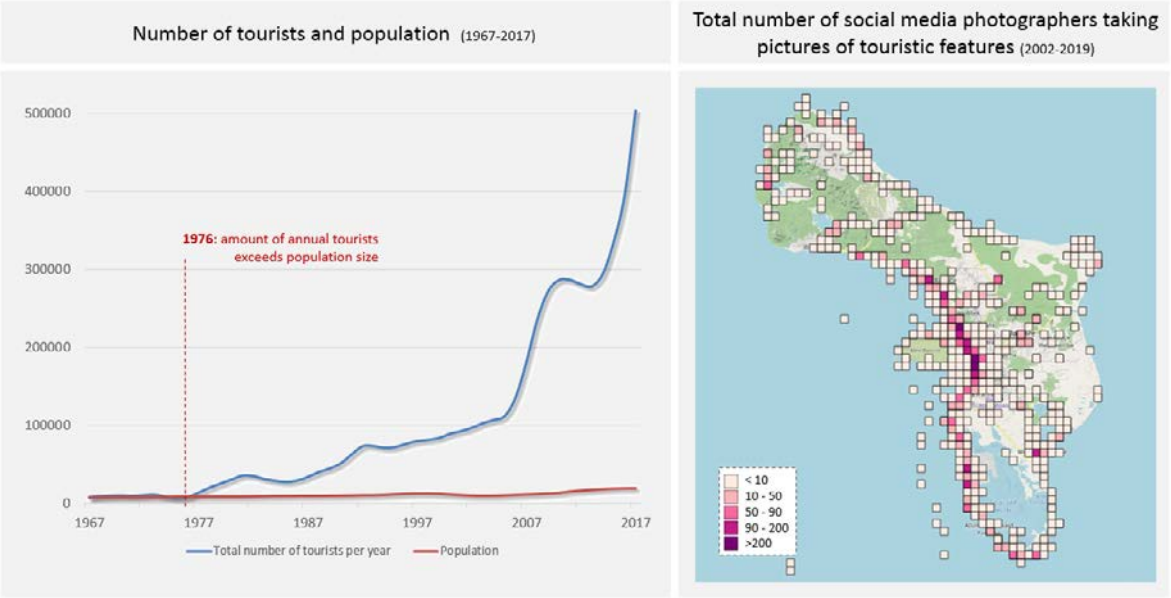



***Figure 6*** *Left graph: trend lines of annual number of tourists (cruise ship tourists plus stay over tourists) plotted against the total population on Bonaire[30, 18]. Right map: a measure of tourism pressure distribution based on social media (Flickr) photo analysis[36,37]*

## 4.5 Recharging fresh water into the soil

Bonaire is positioned in the tropical zone, but has a dry climate as prevailing winds bring little precipitation. Due to climate change Bonaire is expected to receive even less rain. A lot of rain water evaporates before it can sink into the soil and if it infiltrates, it easily seeps away into underground cracks and fissures where it flows over the sloping subsurface to the sea, limiting the supply of fresh water for agriculture and for drinking water. Dams, that held the water for agriculture before, were abandoned during the emergence of the oil industry abroad that attracted workers from Bonaire. Until the 1960's the drinking water supply of the island relied on a few fresh wells[38]. However, as demand increased with increasing population and tourists, desalinization plants were constructed to produce water via reverse osmosis from sea water. Water wells are now primarily used for construction, watering of private gardens and agriculture, as water from desalinization plants is more costly. There has been an extensive drilling of private wells for these uses, which has led to further depletion of groundwater[39]. This extraction of groundwater leads to salt intrusion, making the water unusable for drinking and for irrigation in traditional agriculture and horticulture. Figure 7 illustrates the 2016 water quality in water wells managed by government, showing extensive salt water intrusion in almost all wells. This extensive groundwater extraction and the influx of salt, exacerbated by sea level rise, undoubtedly impacts the natural vegetation and agricultural yields[40, 41].

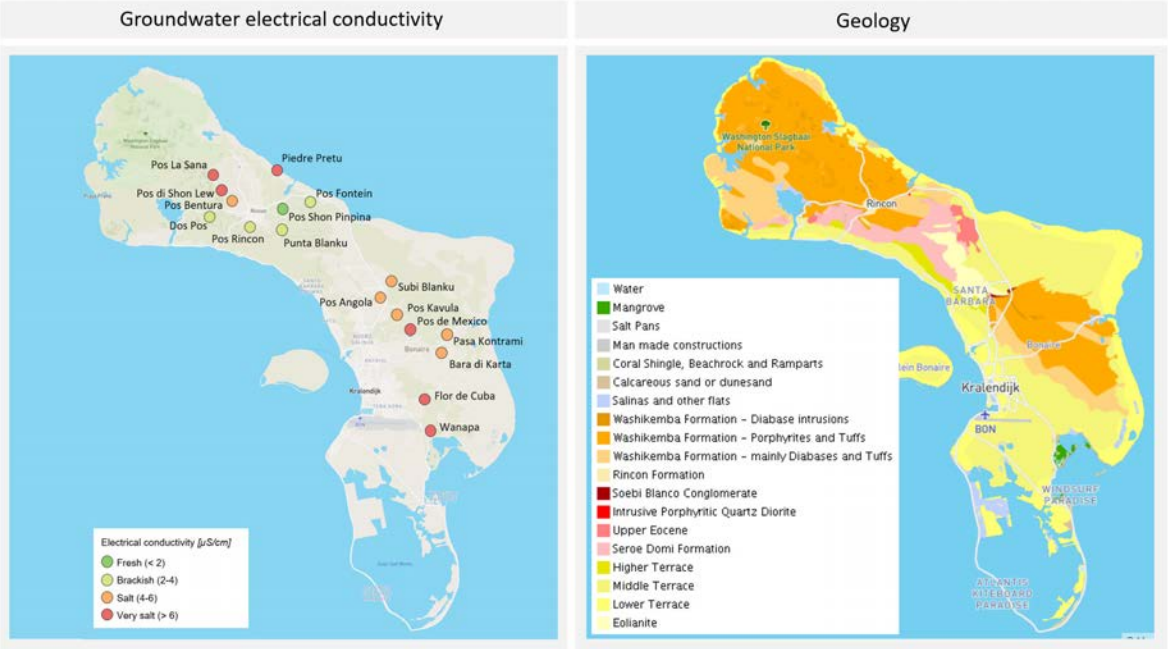



***Figure 7*** *Groundwater salinity measured in wells in 2016 [40] and geological structure influencing the water retention capacity[38, 55]*

## 4.6 Using renewable energy

Bonaire depends heavily on imported fossil fuels for the provision of energy. Currently, 69% of the energy supply originates from burning fossil fuels (equals 300 heavy oil barrels per day). The remaining energy is generated from wind turbines (32%) and solar panels (1%)[30, 42]. As a consequence electricity costs are high and prices are vulnerable to fluctuations depending on oil supply. While environmental conditions on Bonaire offer opportunities for the generation of sustainable wind and solar energy, they require improvements to the electricity network. The global aspiration of reducing greenhouse gas emissions, as agreed upon by all members of the United Nations in the 2015 Paris Agreement, presents a potential opportunity for Bonaire to fund investment in renewables. The Netherlands has set its goal for a greenhouse gas emission reduction of 49% in 2030 compared to 1990. In 2050 the energy supply is to be fully sustainable[43].

## 4.7 Maintaining, enhancing and restoring nature

Bonaire hosts a wealth of biological diversity. Many species are endemic to the island, found nowhere else in the world. Its coral reef diversity and offshore diving attract many tourists. Apart from the marine diversity, the island itself offers diverse habitats that serve as a haven for dozens of animal and plant species, many of which are globally threatened. For example, the island is haven to stable, or even increasing, populations of globally threatened flamingos, which have become a biodiversity, tourist and cultural heritage icon of the island (Figure 8). The land, coast and fringing waters are rich in dry tropical forests and scrublands, caves, beaches, mangroves, seagrass beds and coral reefs. There is an international responsibility for the maintenance and strengthening of its nature, both on land and at sea, as ratified in several (inter)national treaties[44].

Nature on Bonaire is vulnerable due to its small area and inherently small populations of species, making them particularly vulnerable to habitat loss, fragmentation and degradation. Like all islands in the Caribbean region, Bonaire also suffers from invasive alien species and climate change[11] . For example, invasive seagrass is substantially lowering the species density of Bonaire's indigenous turtle grass (Figure 9). Impacts of high (non-indigenous) free roaming livestock numbers, present a major impact on terrestrial ecosystems of Bonaire, as they consume island vegetation faster than it can

regenerate, resulting in low water retention and high erosion rates. Runoff of eroded soil to the sea increases the pressure on marine habitats and in particular, smothers the very coral reefs that currently attract the main tourism [45] (Figure 8). Restoration activities to lower free-roaming livestock numbers, particularly in sensitive areas, and restore vegetation cover, can greatly limit the impact of erosion on land and marine ecosystems.

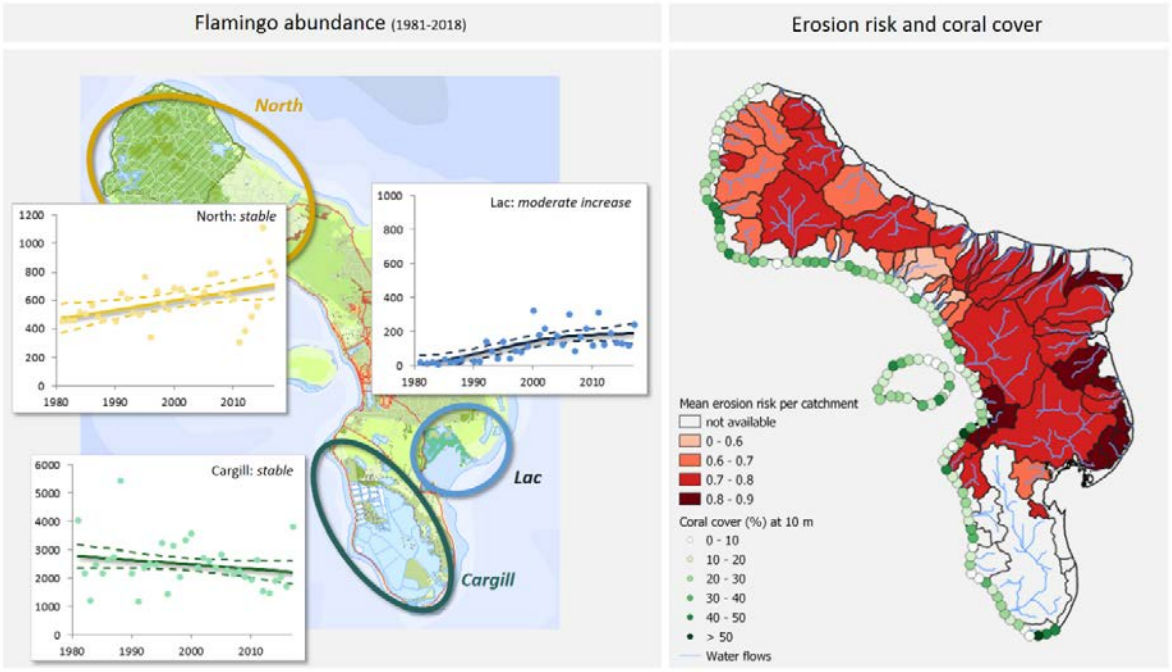



***Figure 8*** *Flamingo abundance[46] and erosion risk with living coral cover of Bonaire[47, 48]*

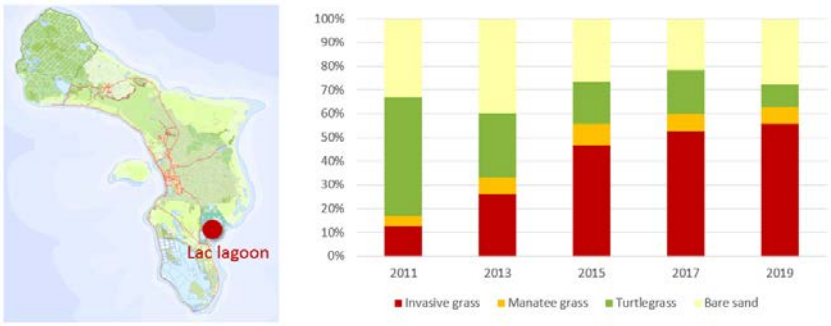



***Figure 9*** *Seagrass species density in central Lac lagoon[49]*

## 4.8 Local produce and healthy diets

Traditionally, food was produced locally on kunukus. Diet comprised mainly goat, chicken, fish and starchy produce (sorghum), with limited fruits and fresh leafy vegetables. Nowadays, Bonaire is 99% dependent on imported food. These imports result in high vulnerability to price fluctuations on the global market and import-restricting policies. Local experts estimate that 40% of the vegetable and fruit needs could be produced locally[50]. Currently home-grown food attracts attention through several local initiatives[51, 52], e.g. the cultivation and selling of indigenous fruit trees by garden centres and horticultural undertakings. Vegetable gardening also helps to some extent to cut down on household food expenditure. However, these types of initiatives and entrepreneurship need to be greatly upscaled to lower the dependency on imported food. This is especially important for the large low income group that suffer from high supermarket prices, as groceries are 40% more expensive than in

the European Netherlands due to the small market, high shipping costs, high refrigerating costs and low supermarket competition[53].

An upscaling of local production also has the potential to improve the overall health and nutrition of islanders. Currently, stews and deep frying are the prevailing way to prepare food, and vegetables are hardly used. Six in ten residents of Bonaire are overweight, of whom half are obese. Women and men are equally likely to be overweight, but obesity is relatively more common among women[30]. Local production of water melon, tomatoes, spinach, lettuce, pumpkin and okra is likely to provide better and more affordable access to more nutritious food. To change the consumption patterns, children are already being educated at primary schools[54], which offers the potential of stimulating increased demand for this sort of local production.

## 4.9 Flourishing cultural heritage

Over centuries, Indian, African, Portuguese, Spanish, English and Dutch traders, slaves and colonists cultures merged to produce a richness in Bonairean oral history, poetic language, architecture, local dishes, music and folkloric dancing.

From the 17$^{th}$ to 19$^{th}$ century, huge tracts of land were turned into private plantations to cultivate medicinal aloe and raise goats for meat and hides, harvesting salt to preserve food, and brazil wood for red dye. For generations Bonaireans lived from the sea (off fish, turtles, shellfish, salt and burnt lime production), or from their small plots of farmland (kunukus) on which they grew the staple grain sorghum (known as maishi chikitu) and tended their goats[5].

Local crioyo (Creole) dishes mainly include stews from fish, chicken and goat, seasoned with native herbs and a variety of fresh vegetables and fruits (pumpkin, plantain, mango and papaya). A popular side-dish is funchi (traditionally cooked with Sorghum flour). These local dishes are barely found on tourist menus.

Arousing interest in the cultural heritage, and the natural and cultural landscapes of Bonaire could strengthen the feeling of connection with the land and the preservation of the values of the area. Offering differentiation in the tourism product through musical and dance presentations and traditional food specialties by locals, is likely to improve the prosperity of the island and well-being of its inhabitants. This diversification also has the potential of improving the resilience of the tourism industry and taking pressure of existing built infrastructure and marine ecosystems.

# 5 Interweaving nature in Bonaire's landscapes – a vision towards the future

In a nature inclusive society, societal challenges are addressed while simultaneously providing benefits to nature. Thus nature inclusive planning measures implemented to combat challenges for any sector, will also strengthen nature. The types of measures applied depends on the local and spatial context: the biophysical, cultural and aesthetic characteristics. The intersection of these characteristics is what makes the landscape of Bonaire so diverse, with its dry cacti forests, traditional kunukus, coralline coasts, biodiverse reefs, extensive salt flats, vibrant villages and interesting traditional cuisine.

Figure 10 shows a landscape map that depicts the intersections of biophysical, cultural and aesthetic characteristics, delineating landscape types to which coherent sets of nature-inclusive measures are assigned. This landscape map was developed using clusters of nature-inclusive measures that were spatially located by local experts on a map of Bonaire, in combination with geological[55], soil[56], elevation[57], vegetation[58], planning[3] and recent high resolution land cover[23] maps.

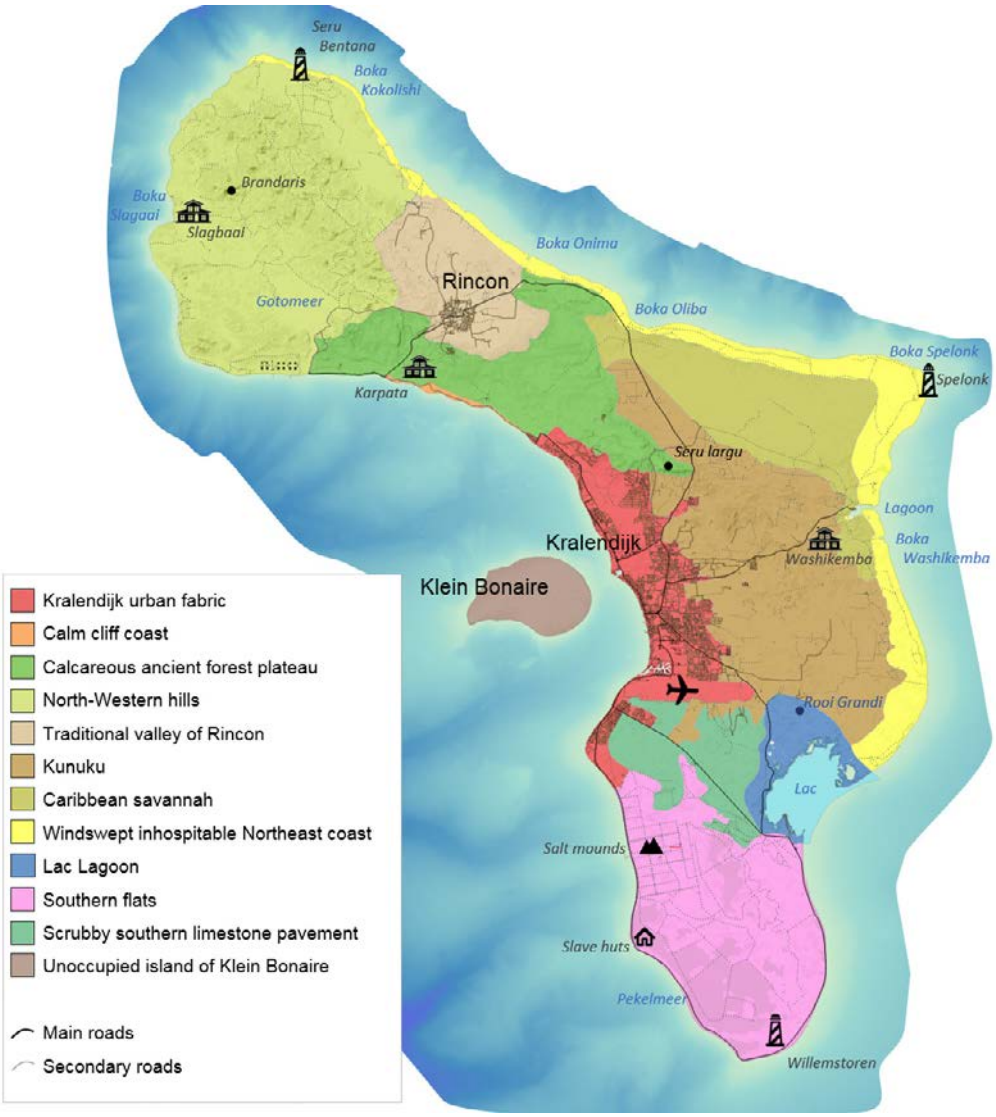



***Figure 10*** *Landscape map of Bonaire. Each type delineates an area with coherent biophysical, cultural and aesthetic characteristics*

A description and aspirational vision for each of the landscape types was also co-developed by the local experts, in which the nature inclusive measures are implemented to combat the challenges that Bonaire faces. These are provided below.

## 5.1 Kralendijk urban fabric

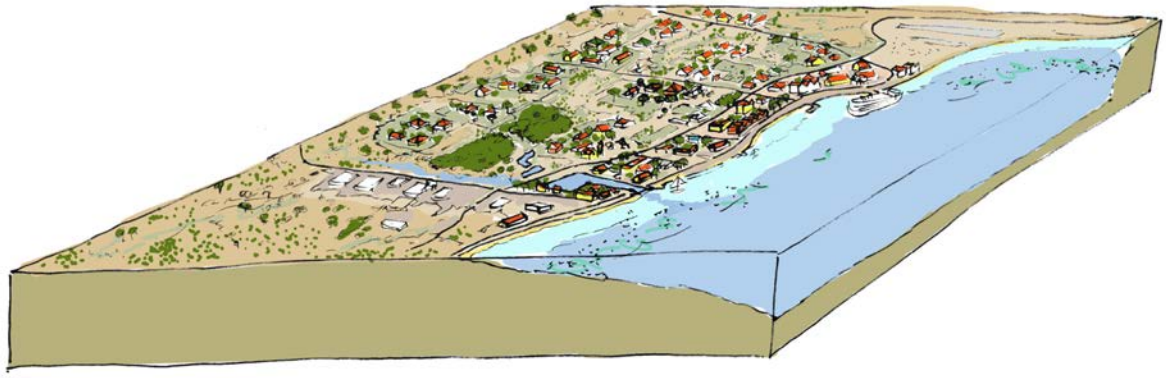
Kralendijk is situated on the inside corner of Bonaire, sheltered from the wind, with calm beaches and easy access to the reef. The entire shoreline of Kralendijk is publicly and freely accessible to everyone, wide enough to protect against sea-level rise and surges, and includes restricted areas for nesting of sea-turtles. Sediment traps prevent soil and dirt to run-off into the sea and on to the corals. Excessive storm water is collected through a system of drains and (partially underground) canals into a natural reservoir. Semi-permeable pavement is used on parking lots and squares to allow rainwater to seep into the soil, recharging the groundwater, and to prevent soil erosion by wind or water.

Kralendijk is the vibrant tourist centre of Bonaire with a variety of locally owned and staffed restaurants serving traditional food. A balanced variety of family inns, hotels and small resorts hosts stay-over tourists. Urban growth takes place within the borders of this zone.

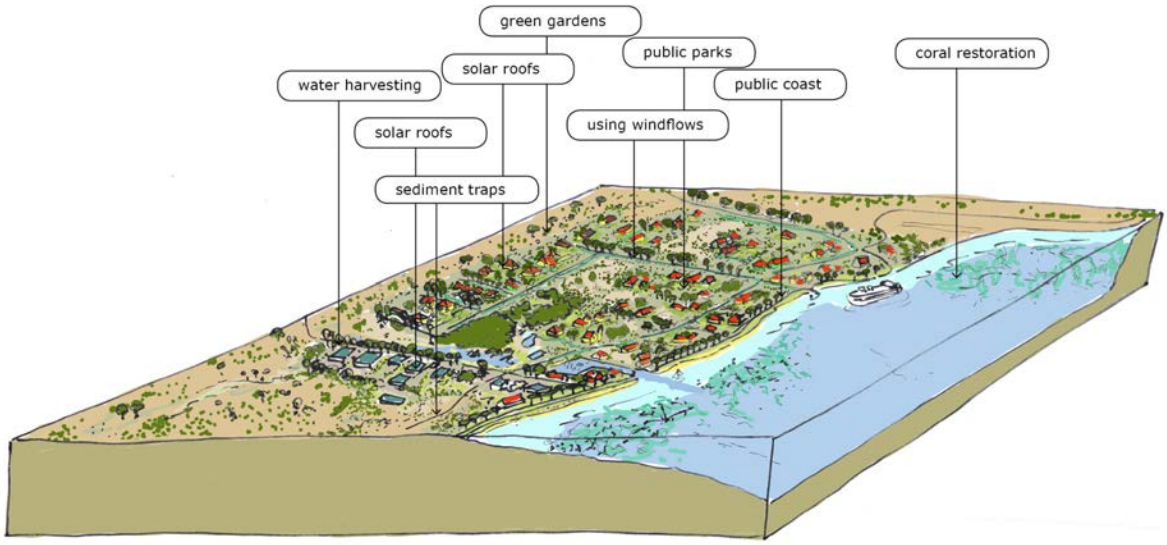
Rainwater is optimally harvested from roads and solar panel covered roofs and stored in cisterns. It is used in gardens, public green spaces and to recharge groundwater. Road verges and (hotel) gardens are rich in indigenous shrubs and trees (including the iconic Sabal palm) and form a green network connecting public parks. The lush green vegetation attracts urban wildlife and the parks are a shaded resting and meeting place for both Bonaireans and tourists. As there is no roaming livestock in town, the green infrastructure can develop undisturbed and the amount of (nightly) road accidents from crossing livestock is absent[7].

Construction of buildings make optimal use of prevailing wind direction, window blinds and shading by vegetation to create a comfortable indoor climate and limit the need for air-conditioning. The use of wells for providing gardening water is in balance with ground water levels. Private drilling for water is well-regulated and enforced.

Just off the coast, coral that suffered from erosion and nutrient overload are now in healthy conditions and capable to grow with fluctuating sea levels.



*Kralendijk – current landscape*

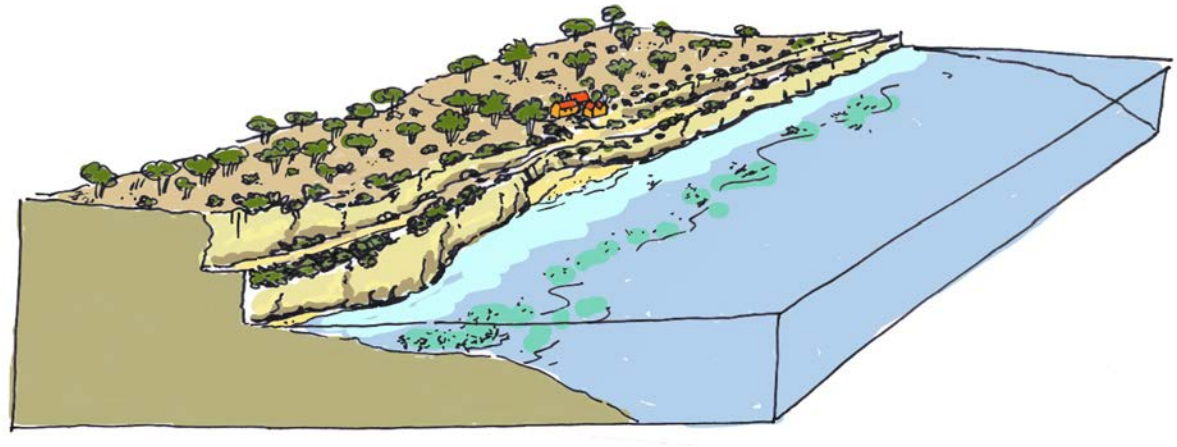



*Kralendijk – future landscape*

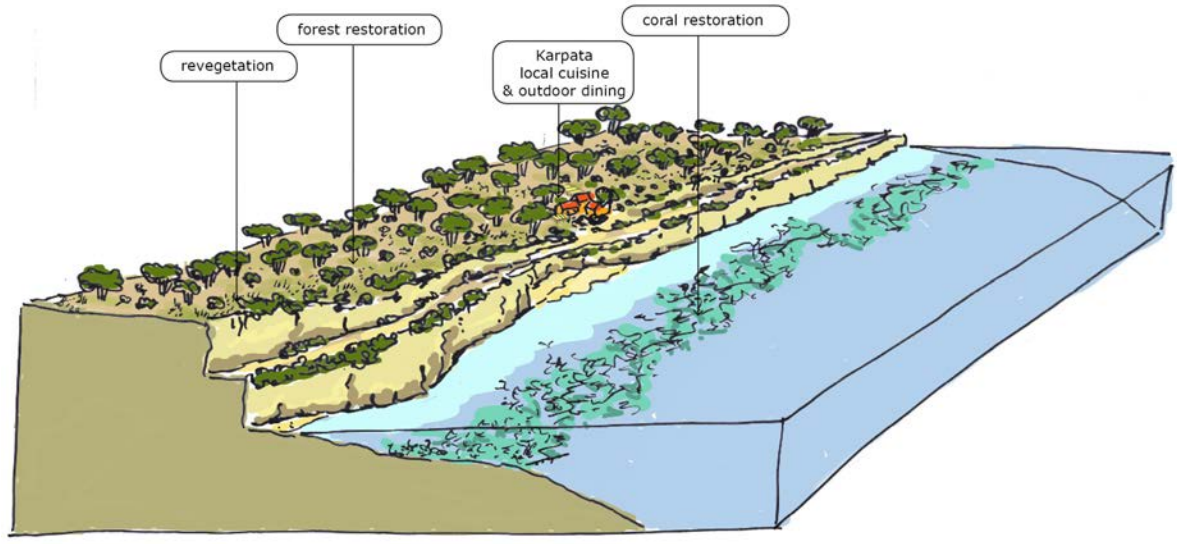
## 5.2 Calm cliff coast

Along the scenic road that meanders along the calm coast from Kralendijk to the northwest, a narrow stretch of land is confined between a naturally terraced cliff that drops down into the sea. The beach is covered with a thick layer of bleached remnants of stone corals. The cliffs are vegetated with characteristic salt tolerant plants, like the Seagrape, the Turk's cap cactus and, further from the shore, ground dwelling bromeliads and the *Prosopis* with special yellow pompom shaped flowers, that contrast with the darkness of the rising cliffs and its caves.

The renovated monumental manor of the former plantation of Karpata accommodates roofed outdoor dining facilities with local cuisine and a beautiful view across the sea towards Klein Bonaire. The dry forest surrounding the manor has been restored to its former glory.



*Calm cliff coast – current landscape*



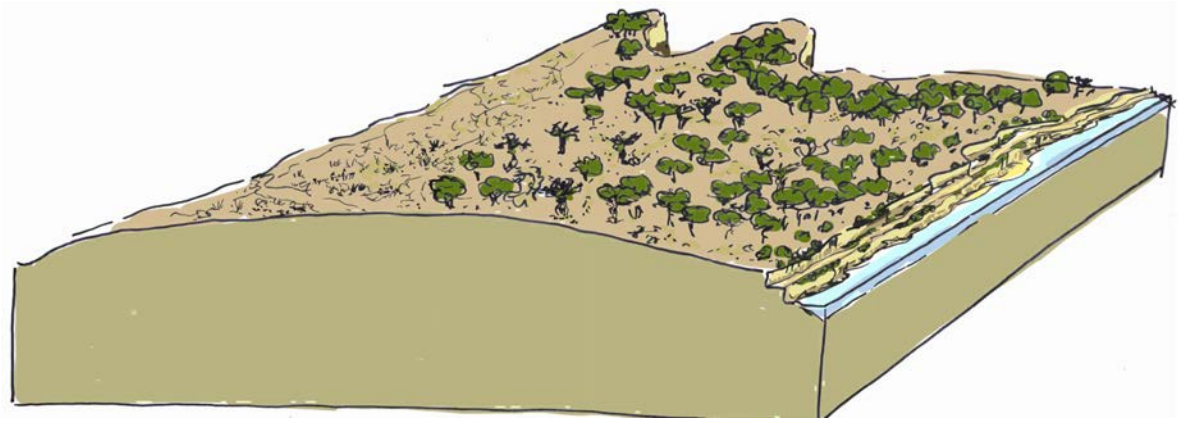

*Calm cliff coast – future landscape*

## 5.3 Calcareous ancient forest plateau

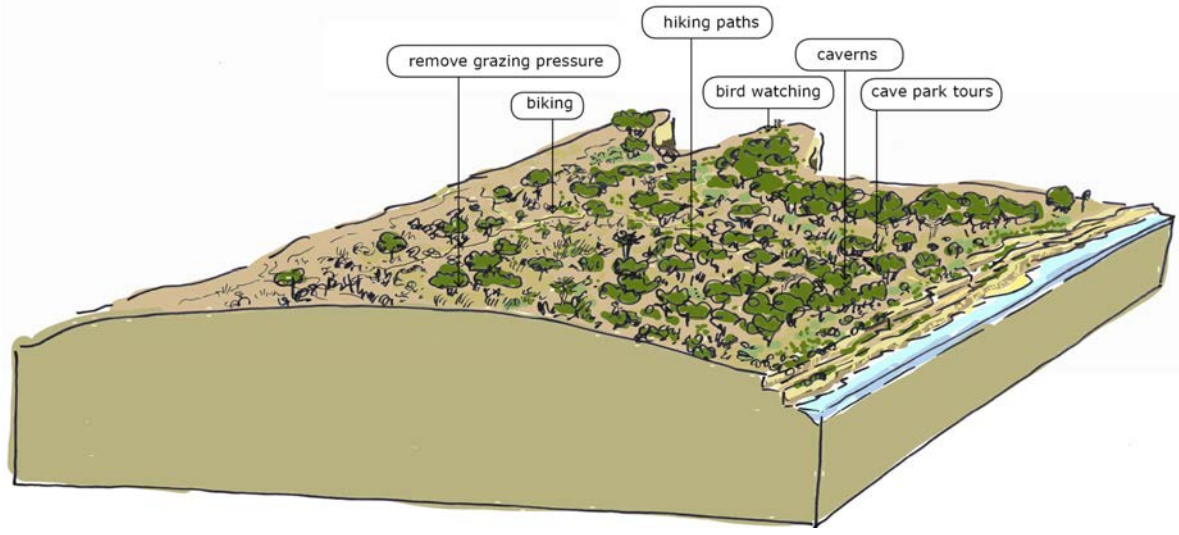
The middle Bonaire limestone terraces were formed by coral reef growth during periods of varying sea levels as the land was lifted up and the sea rose and fell during the ice ages. The limestone cliffs rise up from the shore with nearly vertical steps between the terraces. Rainwater has dissolved the limestone into a sharp-edged karst landscape with sinkholes, caves and limestone ridges, that hampers human entry. Therefore, natural vegetation has mostly been undisturbed and large native trees have been able to develop. These calcareous species are evergreen, keeping their leaves even during the driest months, in contrast to the trees on volcanic soils that drop their leaves in the dry season.

After years of extreme grazing pressure that lead to extreme ecosystem degradation, targeted revegetation actions have helped to recover the forest, which is now rejuvenating and promoting resilience through improved soil retention, water infiltration, nutrient cycling and carbon storage. High-up on the leeward side, pockets of rare orchids grow on these large native trees, in forests that create relatively cool micro-climates and store CO2. Ground-dwelling orchids have developed after removal of roaming livestock as part of the establishment of this terrestrial calcareous forest park. The numerous caverns are home to different species of bats. Fruit trees are common and provide food for colonies of endemic parrots.

The park holds a network of low-impact walking trails that are used by tourists and locals for recreation purposes and to experience the ancient, tropical dry forests. Local islanders offer guided tours for exploration of the limestone plateaus. The highest peak, Seru Largu, forms an attractive viewpoint for tourists as well as local inhabitants, that climb the hill jogging and cycling or enjoy the view during an evening walk.



*Calcareous ancient forest plateau – current landscape*




*Calcareous ancient forest plateau – future landscape*

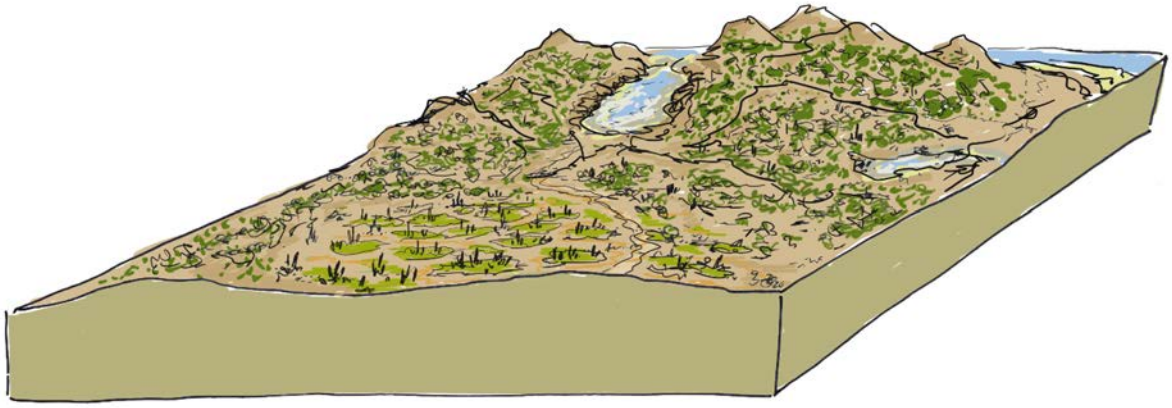
## 5.4 North-Western hills

During the colonial times, the volcanic hills in the north-western part of the island contained two of the largest and most productive plantations. The plantations supplied salt, charcoal, aloe extract, divi-divi pods for use in leather tanning, and goats for export to Curaçao and Europe. In a good year, 3.000 or more goats would be shipped to Curaçao from the bay known as Slagbaai. In 1969, these former plantations were turned into the Dutch Caribbean's first protected nature area, which also acknowledge the rich cultural and historical heritage.

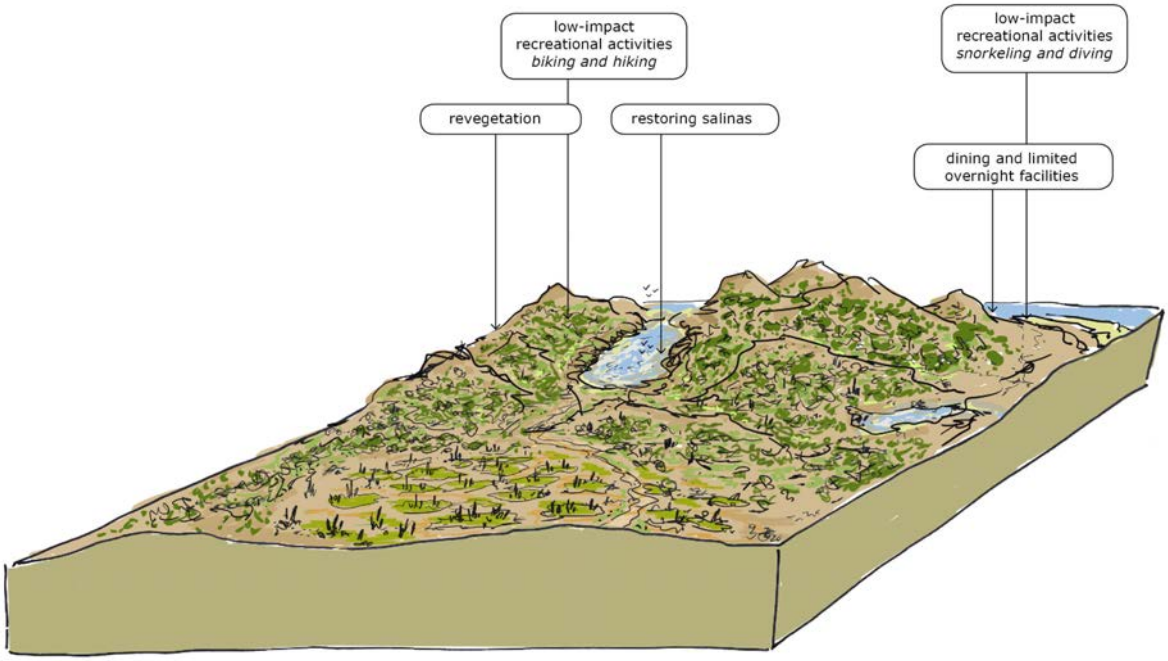
In 2050, the park covers the entire north-western hills and is mainly vegetated with low thorny scrub and cacti, typical of dry environments. Moreover the park is home to a variety of distinctive habitats, including sand dunes, hypersaline lagoons (saliñas) and relatively moist patches with *Tillandsias* (epiphytic Bromeliads) along the south-west coast. The herbal understory has recovered after roaming livestock removal, and the shrub layer and tree layer have become more diverse. After years of extreme grazing pressure, targeted revegetation actions have helped recover the dry forest and promote resilience through improved soil retention, water infiltration, nutrient cycling and carbon storage.

The area provides a safe haven for many of the island's native plants and animals, including parrots, parakeets and iguanas. It is a sanctuary to seabirds, shorebirds and terrestrial birds, many of which use the park as a stopover on their migratory route. Saliñas, such as Gotomeer, are nesting and foraging grounds for many species of migratory waterbirds, among them the endangered Caribbean Flamingo. These saliñas have been dredged to restore the water storage capacity, preventing sediments from smothering the reef.

The area offers a wide range of low-impact recreational activities. These include hiking, birdwatching, mountain biking, snorkelling and diving. Some of Bonaire's most beautiful reefs can be accessed directly from the park's coastline and are now restored. For visitors the former plantation estate offers restaurant and low-impact overnight facilities.



*North western hills – current landscape*




*North western hills – future landscape*

## 5.5 Traditional valley of Rincon

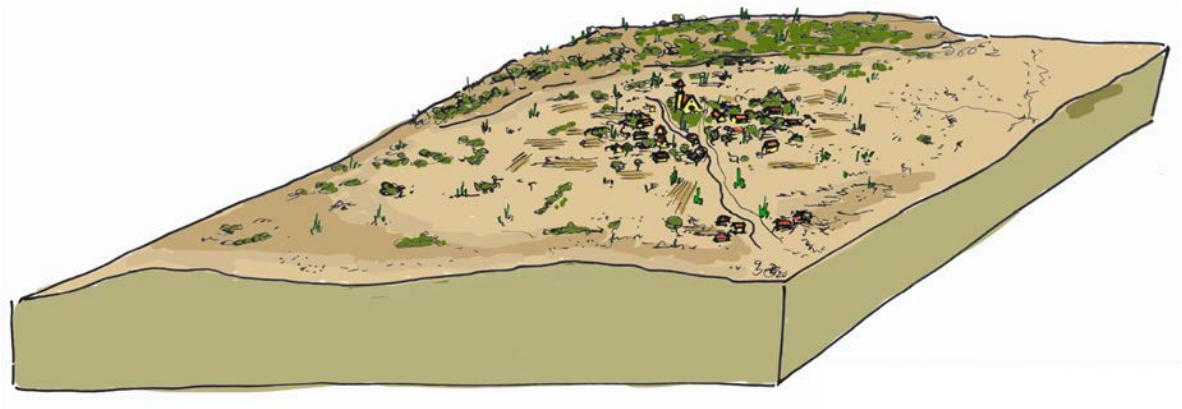
The substrate of Rincon is formed by old volcanic rock that surfaced from the ocean over 60 million years ago. This fertile thick layer is surrounded by calcareous deposits of coral that grew on the volcanic rock. During the rainy season, the volcanic hills erode and fertile material is deposited in the valley. This, together with the occurrence of natural wells, makes the area suitable for small scale agriculture and horticulture.[15]

By 2050, extensive agriculture and livestock raising takes place in the valley surrounding Rincon. The pattern of small fields, wells and paths has developed over the centuries. The horseshoe shaped valley of 2400 hectares lies in the north-western part of Bonaire surrounded by hills. Several natural watercourses ('rooien') drain rainwater from the surrounding hills during the rainy season. Some of these end in an artificial barrier ('dam') to hold the water in the resulting reservoir ('tanki') for agricultural purposes. Fields and gardens are traditionally hedged with cactus fences, which is aesthetically appealing and requires less maintenance than iron fences, which rust quickly in the salt climate. Livestock is kept in corrals, also fenced with cacti.

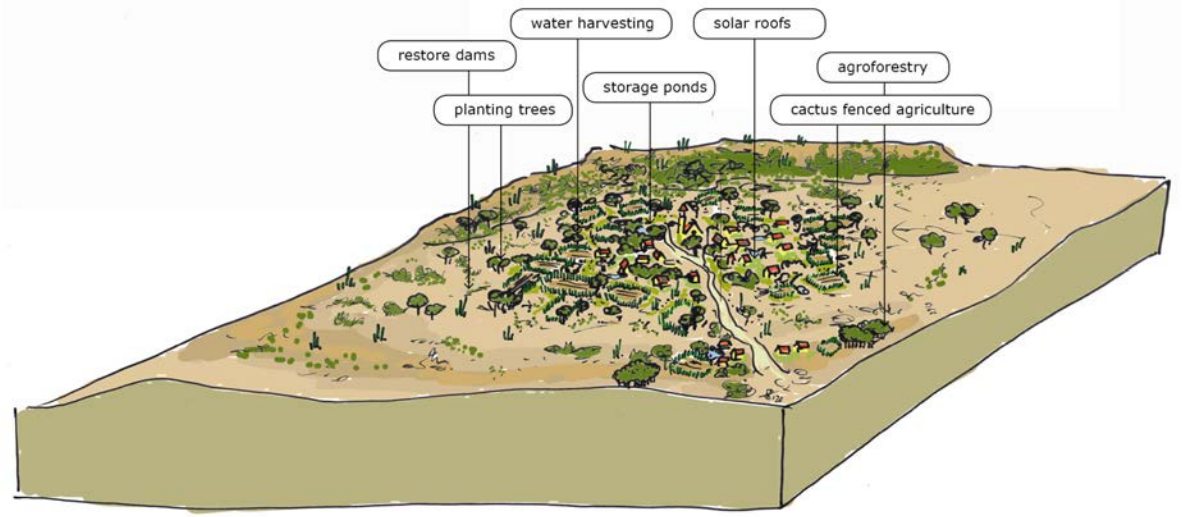
In the centre of this valley lies Rincon, the oldest village on Bonaire that has been occupied since the 16th century. As the original home to Caiquetio Indians from South America and, later, to African slaves, Rincon village forms the cradle of the rich Bonairean culture[61]. Rincon's typical townscape together with its surrounding small agricultural fields is preserved in the form of a landscape park and protected from urban sprawl. The population of just below 3000 in 2017[59] remains stable in 2050. Typically, the fields and gardens are hedged by cactus fences. Agricultural fields produce food for personal use and deliver ingredients, such as pumpkin, plantain and goat meat, for highly-promoted local menus in (specialised) restaurants that target the tourist market. Additionally, gardens are used to improve nutritional value of the diet of the islanders through growing fresh leafy vegetables and fruits, shaded by indigenous (fruit carrying) trees and shrubs. Regenerative agricultural practices including no-till farming, agro-forestry, regenerative grazing are common in Rincon leading to healthy soils and productive farms[60].

A great variety of trees are abundant in the village and the surrounding agricultural fields and provide shading, prevent erosion, enable water recharge and are a rich habitat for the abundant wildlife such as iguana and parrots. Rainwater is harvested from rooftops and well-maintained canals, dams and ponds. The rainwater is used to water gardens and crops. The number of wells and their use is regulated and enforced. Natural watercourses are deepened and widened to restore the water storage capacity.

Rincon is an attractive landscape and culture park for tourists that may visit the museums and locally owned restaurants on a day trip. To maintain the typical character, the daily number of tourists to the Rincon valley is restricted. Rincon hosts a small number of family inns and country retreats for stay-over tourists.



*Valley of Rincon – current landscape*




*Valley of Rincon – future landscape*

## 5.6 Kunuku

Previous to European discovery of Bonaire, the Caiquetio Indians of South American settlers built small dams to retain the rainwater growing mainly sweet potato as they did in their South American country of origin. These dammed lands were called 'Conuco'. With the abolishment of slavery, former slaves were able to rent small plots of land surrounding residential areas for subsistence farming. This was the beginning of what we now know as the kunuku landscape. The kunuku provided livestock, aloë, dividivi pods for leather tanning, charcoal, goat dung as fertilizer, goat skin, sorghum, maize, beans, vegetables and fruits. While the residents lived on the kunuku's, many of them owned another house in villages, that are now part of Kralendijk, to be able to attend the church service during weekends. Houses were built through barter trade and as favour in return[5].

While Bonaire's leeward shore of Kralendijk is fringed with hotels, shops and restaurants, the agricultural kunuku areas in the countryside remain peacefully quiet. Marked, unpaved routes for cars, mountain bikers and hikers guide tourists through the kunuku landscape and point out interesting natural and cultural sites. Several manors of estates on former plantations are renovated and accommodate roofed outdoor dining facilities that are well known for their local cuisine. These have become popular attractions for locals as well as tourists. These associated manors exhibit historical use and local life.

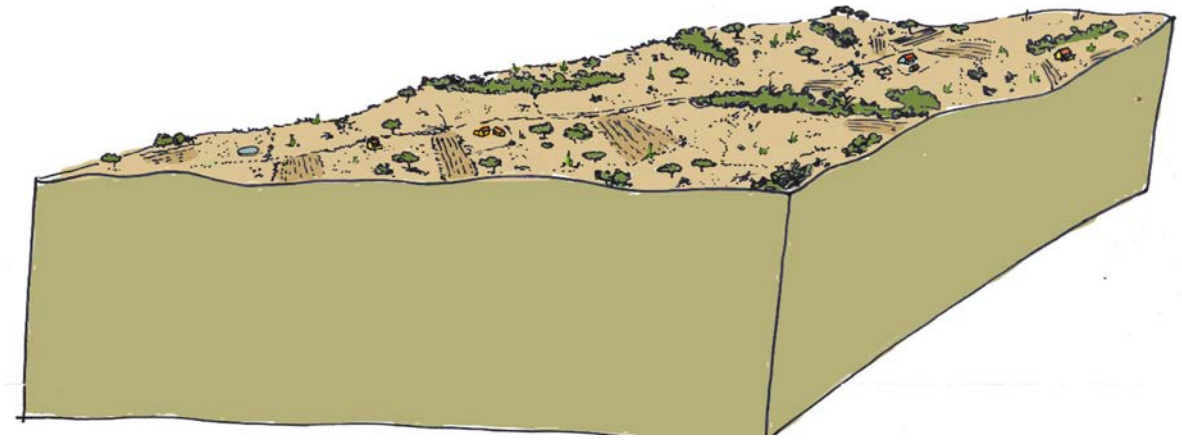
Several aloe farms are located in the kunuku area. This crop is well-adapted to the dry conditions. The plants grow in the rainy season and are harvested for the pharmaceutical industry at the end of the wet season when the leaves have the most juice. These farms can be visited and have a small shop for selling high-end, home-made nourishing body creams.

Through investments, horticulture produces a vast amount of fruits and vegetables that are well adapted to the local climate and are locally sold. Shaded horticulture protects the plants from the fierce sun and drip-irrigation ensures that watering fully benefits the plant. In addition to shaded greenhouses, solitary trees, tree rows and small fruit tree orchards provide protection against the sun. To limit maintenance of the drip-irrigation system, only perennial crops, like okra and papaya, and orchard fruits like soursop and tamarind are grown. Horticultural activities take place close to the island's sewage treatment plant and several communal desalinization units to maximize benefits of water provision and circular value chains. Each desalinization unit produces enough water for about 50 horticulturists per day and runs completely on solar and wind energy generators, which are integrated into all desalinization units. Water may be transported by lorry from unit to farmer. Horticultural farmers own a limited number of goats for their consumption, which are fed by residues from their farm. These small-scale farms form an attractive mosaic landscape.

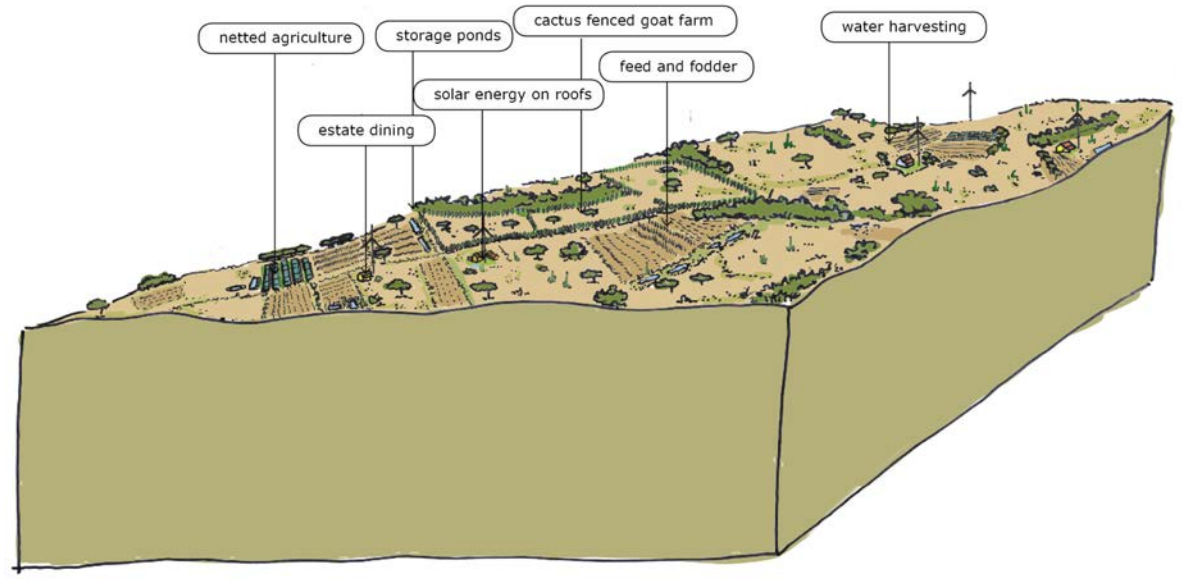
Larger scale goat farming takes place in a dedicated zone, where all goat farms are concentrated. Typically the fields are fenced by cactus hedges to keep the goats in and prevent them from damaging farmland, gardens and nature. Solitary trees in the fields provide shading to the goats. Fodder for the goats in this area is produced and processed into hay. Fodder is grown in strips, so that the irrigation system can remain in place while sowing and harvesting. Goats produce meat for the consumer market, local restaurants and as high quality export product for the wider Caribbean region. The valuable, soft goat skin is used to produce bags and purses, as well as drumheads. Goat dung is used as fertilizer for fodder production and in horticulture.

Water harvesting in the kunukus, which had largely been abandoned in the 1960s, is resumed, with water again harvested in strategically located dams and artificial ponds ensuring the availability of additional rainwater in the dry season. To maintain the level of the water table and prevent the natural vegetation from drying out, the use of wells is limited.

Electricity production is decentralized and produced at sites where it is needed. Solar panels are placed on farm-houses and sheds, and yards are provided with a small wind-turbine.



*Kunuku – current landscape*



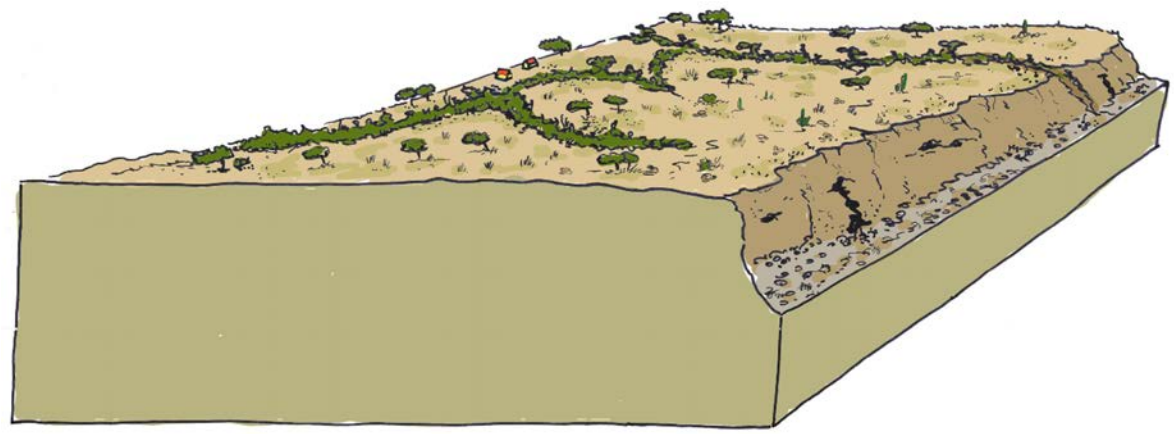

*Kunuku – future landscape*

## 5.7 Caribbean savanna

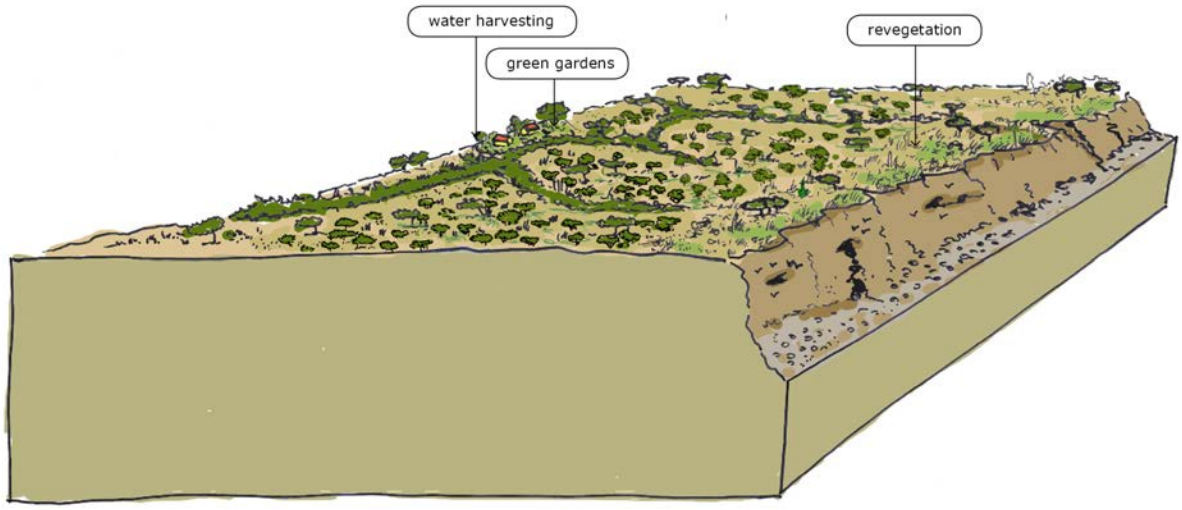
This landscape is part of the former plantation Bolivia. It strongly resembles a savanna landscape, with a dry grassy herbal plain dotted with solitary umbrella shaped trees. Centuries ago it was densely covered with trees, which disappeared as result of harvesting of Brazil wood (providing the raw material for dye) and Wayaká wood (with self-lubricating characteristics ideal for ship pulleys), charcoal production and extensive free roaming goat keeping[5]. In addition to horses and mules that were raised for export, this was one out of three areas on the island where cows were bred for meat. During the wet season the cows would graze on pastures ('sabanas') and during the dry season they dwelled in the forested areas[61].

Nowadays, the Caribbean savanna is intersected with dry river beds ('rooien') vegetated with dense thorny shrubs. Old plantation buildings, corrals and fences for livestock and various abandoned wells can be found in the area.

The future vision for the Caribbean savanna is a landscape where feral, free-roaming livestock has been removed to allow the vegetation to naturally develop into a lush dry forest. The fringing cliffs at the seaward end of the area are revegetated to prevent erosion runoff, and consequent sedimentation of the reef off the coast. This revegetation also provides habitat for the characteristic wildlife of the dry forest and protects the underlying caves that are home to migratory bats



*Caribbean savanna – current landscape*

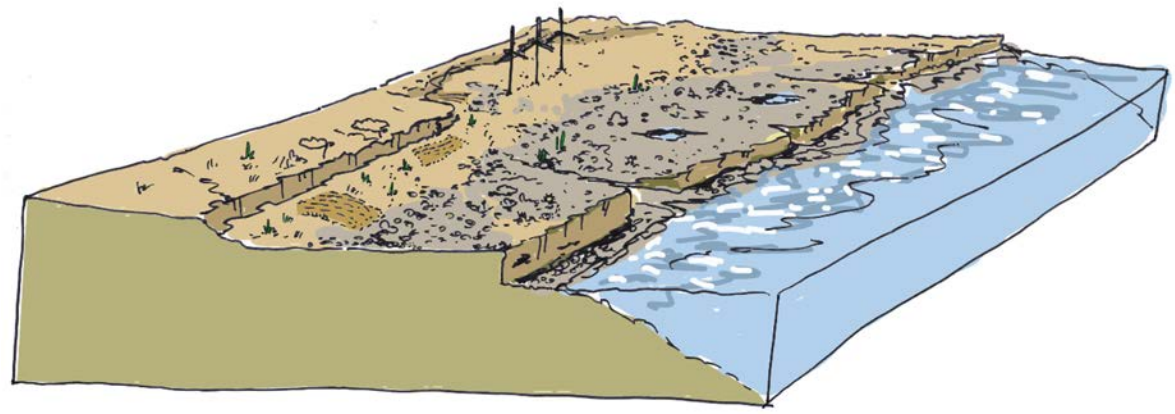



*Caribbean savanna – future landscape*

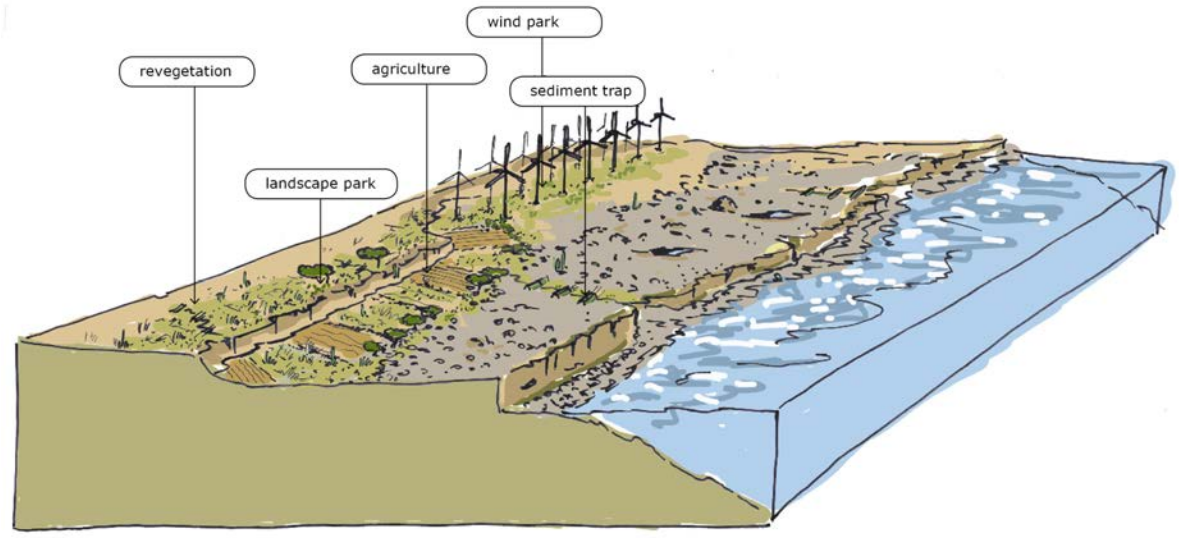
## 5.8 Windswept inhospitable Northeast coast

At first sight, the Northeast coast evokes associations of a desolate moon landscape or salt sprayed wasteland, confined between the sea and a rising cliff. Despite this seemingly barrenness, the landscape park is home to the Turk's cap cactus and nesting ground for the endangered Least tern. For the Caiquetio Indians, the first inhabitants of Bonaire, the area housed many sacred places, that can still be recognized from cave paintings and oral history. Bats (both migratory and stationary) sleep in these caves during the day and use them to deliver and nurse their young. The coast is characterised by the several 'bocas' or small bays, in which dry river beds discharge during the rainy season. A storm berm of coral rubble, sand dunes and boulders is located at some distance behind the intertidal splash zone. In most areas, however, these sand dunes and rubble berms have been mined for use in construction, leaving barren rock. The loss of these sand dunes, which 'soften' the impacts of wave energy, reduces the resilience of this (now hardened) coastline during sea storms [61, 62].

In the landscape park, only pockets of land are in use. Few small parcels of agricultural fields can be found at the base of the cliffs where groundwater seeps to the surface and upstream of the bocas. Here, a patchwork of lush green natural vegetation is found around the rare agricultural plots. Sediment traps capture eroded soil to protect the reef in front of the coast. Wind parks generate a large part of the island's energy. The wind turbines are placed further inland to prevent salt spray damaging the constructions and are located in such a way that they do not hinder migratory bats.



*Windswept north eastern coast – current landscape*



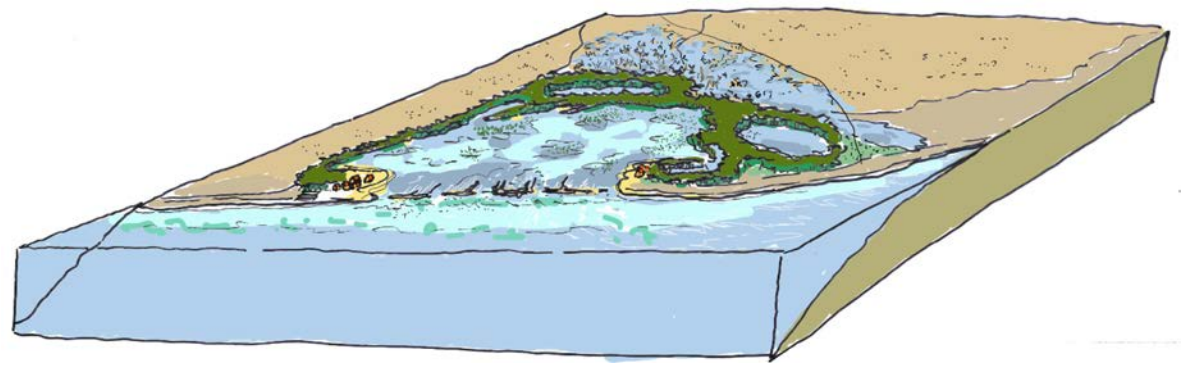

*Windswept north eastern coast – future landscape*

## 5.9 Lac lagoon

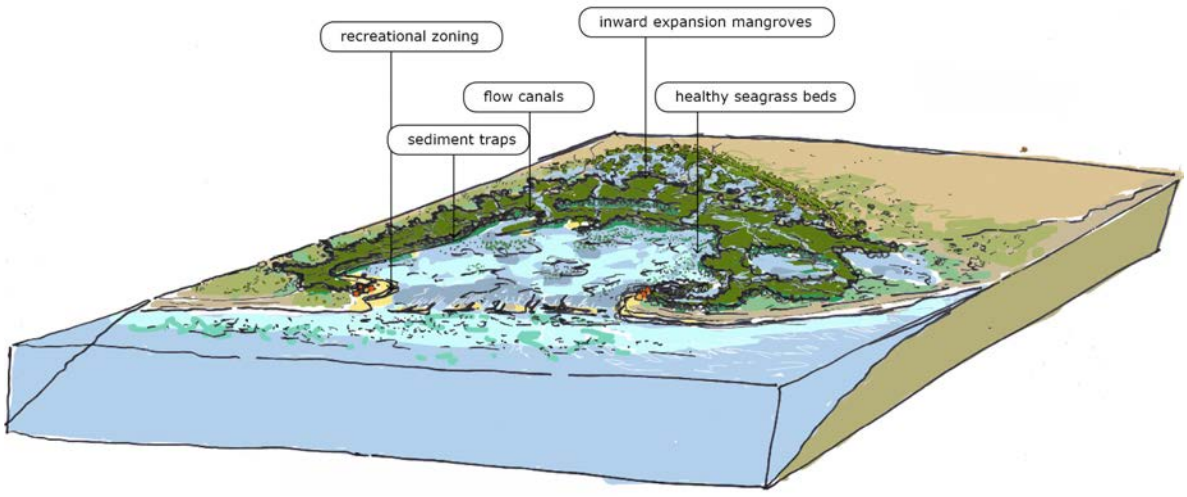
The area of Lac is a sheltered shallow inland bay located on the south-eastern shore of Bonaire and is the island's most significant lagoon. It contains thriving seagrass and algae beds, and healthy and rejuvenating mangroves, and is an important nursery site for conch and many species of reef fish as well as being a critical foraging ground for globally endangered juvenile green turtles. Half of the area consists of open water and the other half is separated by a formation of islands that consist of shallow, muddy basins fringed with mangroves. Lac is separated from the ocean by a fringing reef. Lac is recognized as a wetland of international importance[63], and benefits from special protection. Lac supports large numbers of breeding and wintering shorebirds and seabirds, such as the Magnificent frigatebird and the Caribbean flamingo[64].

In the vision for this landscape, the area surrounding Lac is free from roaming livestock. North of Lac natural waterways ('rooien') have been deepened and dams from rooi Grandi eastwards have been constructed to prevent surface runoff and allow the fresh water to drain slowly. The north boundary has been reforested to capture soil from the hinterland[65], that would otherwise discharge into the mangroves and seagrass beds, suffocating life. Within this new forest, shaded picnic spots have been located. To conserve Lac and prevent the mangroves growing bay-wards, canals have been cut to improve the through-flow[66]. Without these active measures the mangrove forest would extend into the bay and would die off at the outer edge, leaving a salt plain. Mangroves are also re-planted at the outer edge to capture carbon in the peat substrate. The canals in the mangroves are ideal for kayak tours, where tourists are informed about the unique functioning of the mangroves with its special wildlife. The seagrass beds have been restored and are restricted from damaging leisure activities, like surfing. Tourism pressure is kept within sustainable limits so that it does not harm the natural environment.

Although small-scale, Lac hosts the biggest fishing harbour of the island.



*Lac Lagoon – current landscape*



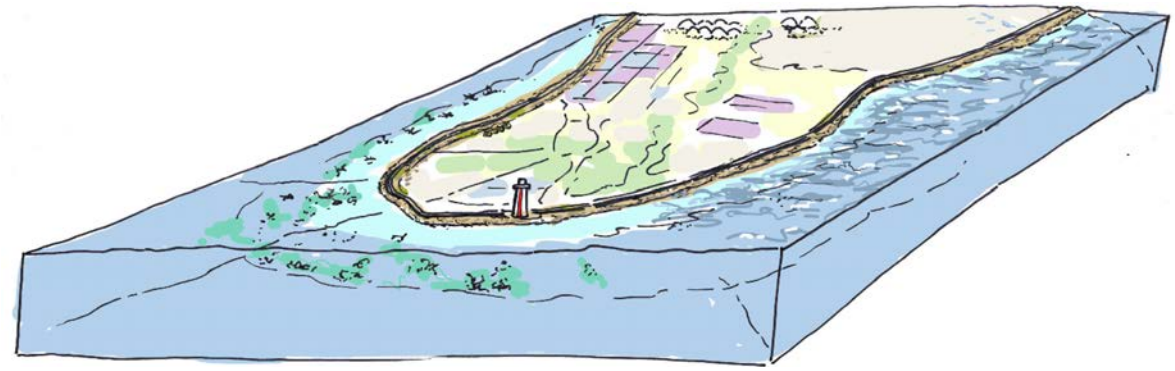

*Lac lagoon – future landscape*

## 5.10 Southern flats

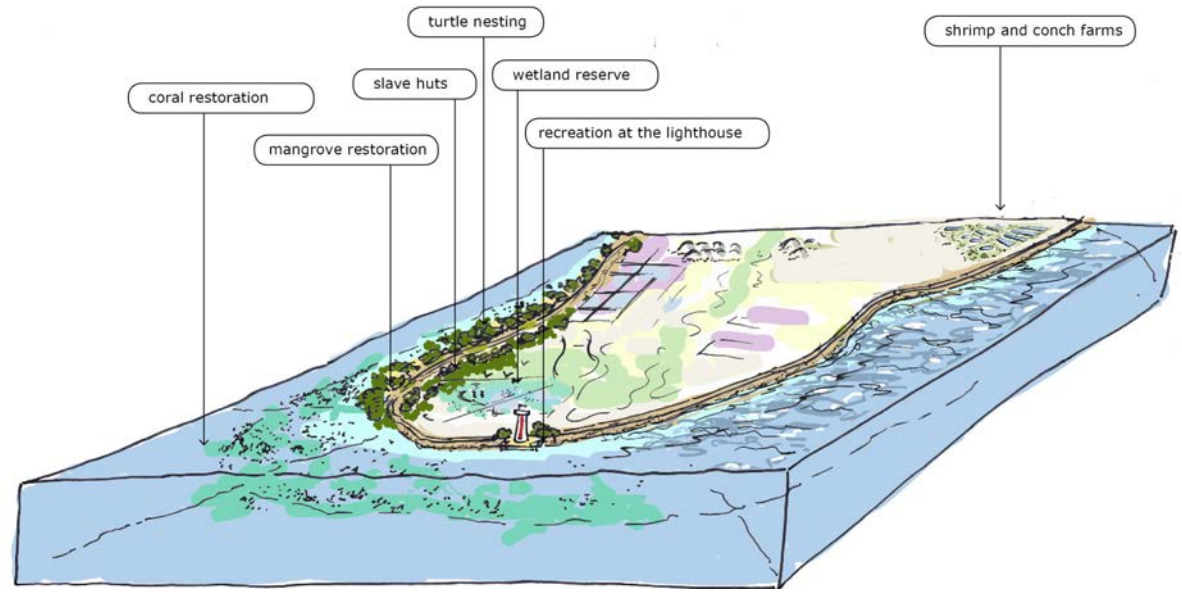
Natural dikes of coral debris surrounded the low lying southern part of Bonaire protecting it from the sea. The natural coral dikes were excavated for building material for houses and a foundation for road construction in general and around the southern coast in particular in the 1950's[61]. This has substantially increased the coastline's vulnerability to sea storms and flooding.

In 2050 the salt pans cover most of the narrow, sea-level southern end of the island and form an extensive habitat for the unique biodiversity including Bonaire's flagship species the Antillean flamingo, nesting terns and migrating shorebirds, as they have done for decades. Part of this area is actively managed for salt production, with seawater being pumped (using wind mills) into a series of condenser ponds to increase the salinity of the water. The salt is harvested about once a year from crystallizer ponds. Direct discharge of industrial effluent is prevented [67]; instead the brine effluent is used for the production of brine shrimp (live food for fish) as a high value commodity export product. In other parts of the area floating sea weed farms provide the bio-pharmaceutical industry with high-value raw material [68, 69].

Along the west coast, healthy reefs and lush mangroves protect against sea storms and flooding and grow with the rising sea. This allows the natural reformation of coral debris dikes. On specific locations, tourists are offered a resting place with a magnificent view over the salt mounds, a cultural heritage of slave huts, a lookout for birding or a diving spot. Existing infrastructure and buildings have been pulled back from the coastline, to reduce their vulnerability to damage from sea storm and flooding. This also provides the opportunity for making the entire shoreline publicly and freely accessible to everyone, except for pockets of habitat for nesting sea-turtles and seabirds. Just south of the Lac lagoon landscape, shrimp and conch are grown in special aquaculture facilities.



*Southern flats – current landscape*



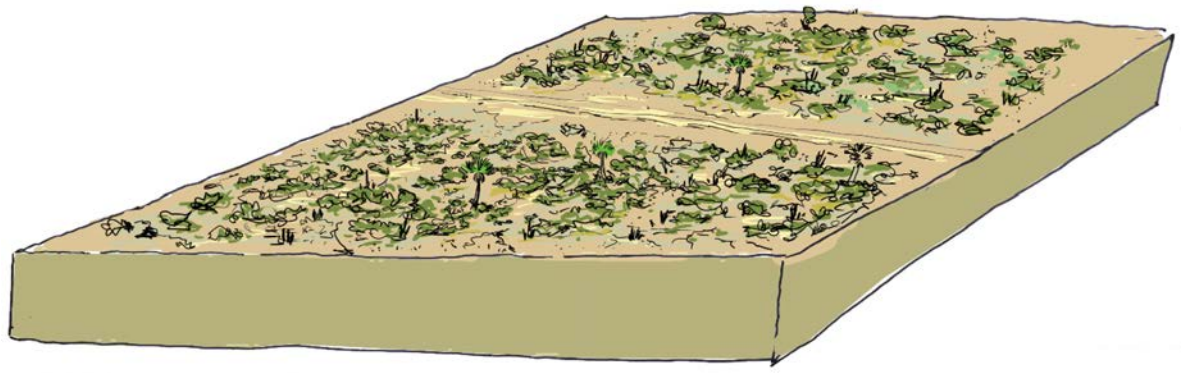

*Southern flats – future landscape*

## 5.11 Scrubby southern limestone pavement

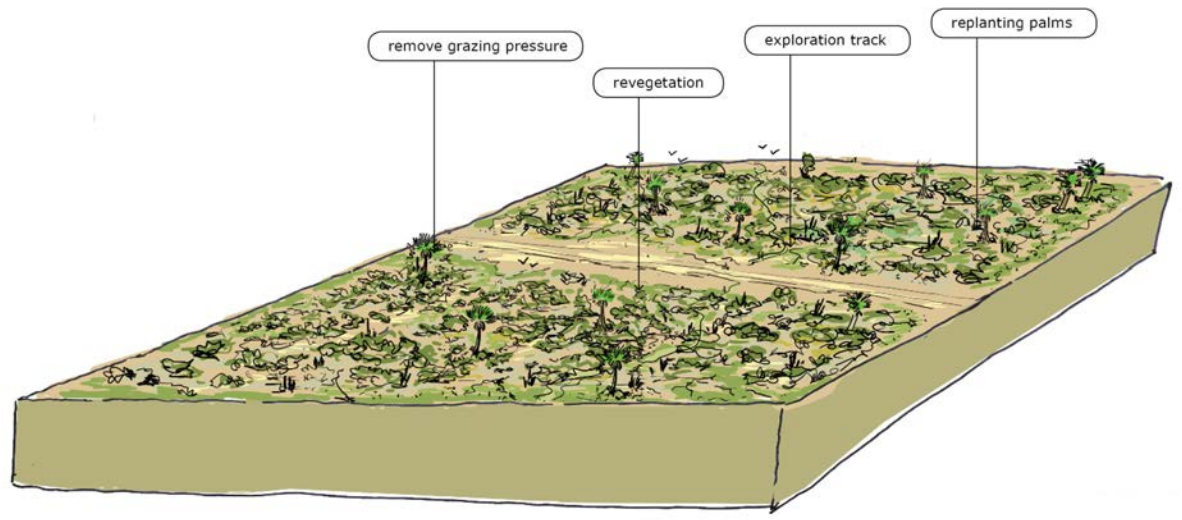
The rock-hard calcareous substrate, strong winds, and salt blown in from the sea makes this area inhospitable for human activities. Scrubby plants and cacti grow in the holes and cracks in the limestone pavement, as well as the indigenous and iconic Sabal palm, native solely to Bonaire[70]. In the dry season, shrubs drop their leaves on the volcanic soils and this area bursts with berry carrying plants, attracting songbirds.

Conservation efforts have been put into place to protect it from feral herbivores. Fences have been installed to give new Sabal palms a chance to grow and to keep free roaming livestock outside of the entire area. In addition, a large number of palms have been successfully cultivated and replanted in the area to help expand the population. This landscape type harbours a sustainable and large population of Sabal palm in a well-developed forest and shrub vegetation, that also hosts extensive populations of bird, reptile and insect species and forms an important sink for $CO_2$.

A trail through the area enables exploration of the area, but entrance is restricted to tours lead by local guides from the nearby villages.



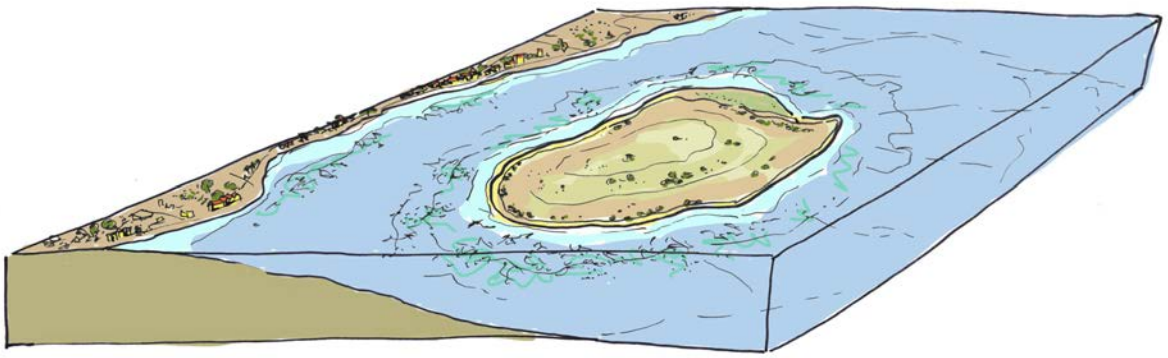
*Scrubby southern limestone pavement – current landscape*



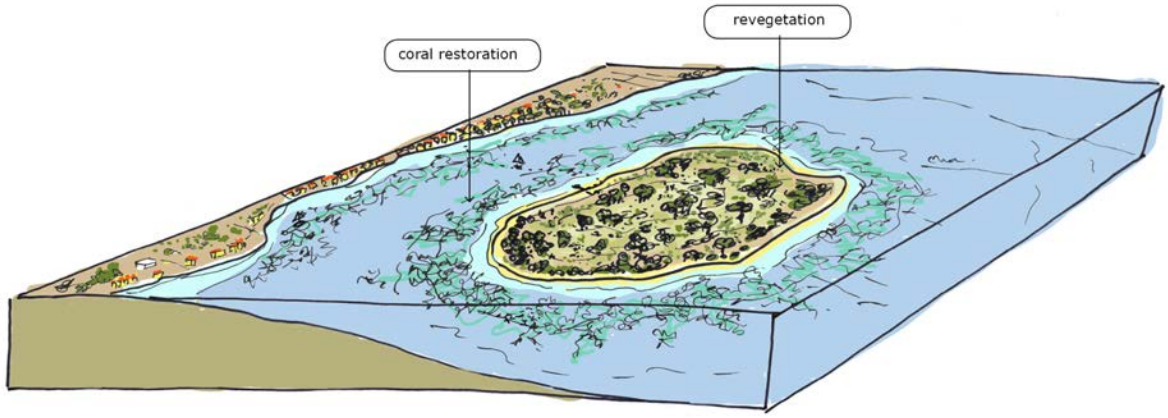

*Scrubby southern limestone pavement – future landscape*

## 5.12 Unoccupied island of Klein Bonaire

The small offshore island of Klein Bonaire is located approximately 750 metres off the central west coast of Bonaire, separated by a strait of almost 200 meters deep. It is a low sandy coral-limestone island fringed by restored reefs that support an extremely rich marine fauna. The total land area of approximately 6 km² includes saliñas, freshwater wells and sandy beach areas. The sandy beaches are vital nesting areas for sea turtles. The island is a stop-over point for countless species of migratory wetland birds, and an important breeding site for terns. In the past, Klein Bonaire was covered with forest. Years of logging, devastating storms and all-plant devouring goats cleared the island completely. The eradication of goats since the 1980s and active replanting of indigenous trees has set in motion advanced recovery of the island's vegetation in 2050[71]. The island is uninhabited but people visit the island daily, mostly for having a picnic, for snorkelling, diving, birding, hiking and sea turtle conservation activities. The number of visitors to the island are regulated to limit disturbance to animals (e.g. birds and turtles) and habitats (e.g. reef), and to enjoy it's peaceful ambiance and unsurpassed natural beauty.



*Klein Bonaire – current landscape*




*Klein Bonaire – future landscape*

# 6 Next steps: stimulating uptake and impact

This report brought together the knowledge of island experts and decision-makers from nature, agriculture, recreation, culture and government. The enthusiasm of the participants in the design sessions, interviews and workshops, as well as the sharing of experiences with other local islanders evoked a snowballing effect: a growing community of supporters have expressed the desire to include 'nature inclusiveness' in their own ongoing initiatives. The vision developed for Bonaire is aimed to inspire Small Island Development States all over the world.

This work is ongoing, iteratively incorporating the knowledge of a growing body of islanders over time, intended to catalyse the implementation of nature inclusive measures that have been collectively identified. The nature of the next iteration will depend on the feedback from the local experts and the needs that emerge, and could include:

- ex-ante assessment of the suitability and feasibility of planned measures, e.g. What are suitable locations for measures? How does nature benefit from the measures? How much brine is produced as residue from reverse osmosis and what can be done with it (e.g. careful disposal off the rough northeast coast)? How much households can earn a living of the locally produced food? What are economic implications? How can potential development of the Caribbean Savanna and accompanying infrastructural works like water, sewerage and energy, be realized nature-inclusively? How much agriculture can take place at the cliff foot of the windswept inhospitable Northeast coast? Can Sargassum washed ashore be used as fertilizer? etc.;
- the development of several micro-scale exemplary implementation projects (each on a different theme);
- several champions promoting the transition to a nature inclusive society.

These appealing pilots promoted by champions are the basis which could inspire others to latch onto and help to generate broad social consensus and momentum for implementation.

# 7 Used resources


1 Commission Pourier, 1992, Rapport van de Commissie Integrale Sociaal-Economische Aanpak Bonaire, retrieved from https://www.dcbd.nl/document/rapport-van-de-commissie-Integrale-sociaal-economische-aanpak-bonaire

2 Netherlands Antillean Department of Environment & Nature, 1999, retrieved from https://www.dcbd.nl/document/natuurbeleidsplan-bonaire-1999-2004

3 Openbaar Lichaam Bonaire, 2010, Spatial Development Plan of Bonaire, retrieved from https://www.dcbd.nl/document/ruimtelijk-ontwikkelingsplan-bonaire

4 Van Werven et al., 2010, Masterplan strategische ontwikkeling Bonaire 2010-2025, retrieved from https://www.dcbd.nl/document/masterplan-strategische-ontwikkeling-bonaire-2010-2025

5 Government of Bonaire, 2010, beleidsnota cultuur Bonaire, retrieved from https://www.dcbd.nl/document/beleidsnota-cultuur-bonaire

6 Ministry of Economic Affairs, 2010, Nature Policy Plan The Caribbean Netherlands, retrieved from https://www.dcbd.nl/sites/www.dcbd.nl/files/documents/ez-bo-bw-natuurbeleidsplan-car-nl-eng-2.pdf

7 Openbaar Lichaam Bonaire, 2014, Beleidsvisie 2014-2029 Landbouw, veeteelt en visserij Bonaire, retrieved from https://www.dcbd.nl/document/beleidsvisie-landbouw-veeteelt-en-visserij-bonaire-2014-2029

8 Wayaka advies & BAAB bv, 2018, POP Bonaire: rural development program: 2014-2018, retrieved from https://www.dcnanature.org/wp-content/uploads/2018/08/BioNews-2018-13-POPbonaire.pdf

9 Croes et al., 2017, 2017-2027 Tourism: synergizing people & nature for a better tomorrow, the Caribbean's 1st blue destination, retrieved from https://www.dcbd.nl/document/tourism-synergizing-people-and-nature-better-tomorrow-2017-2027

10 Openbaar Lichaam Bonaire, 2020, Natuurplan Bonaire 2020-2024, retrieved from https://www.dcbd.nl/document/natuurplan-bonaire-2020-2024

11 Ministry of Agriculture Nature and Food Quality & Ministry of Infrastructure and Water Management & Ministry of the Interior and Kingdom Relations, 2020, Plan voor land en water – beleidsplan natuur en milieu Caribisch Nederland 2020-2030, retrieved from https://www.dcbd.nl/document/plan-voor-land-en-water-beleidsplan-natuur-en-milieu-caribisch-nederland-2020-2030

12 Retrieved from https://masterplanbonaire.com/

13 Van Doorn, A., Melman, D., Westerink, J., Polman, N., Vogelzang, T., Korevaar, H., 2016, Natuurinclusieve Landbouw, food for thought, https://doi.org/10.18174/401503

14 Bonhata & Tourism Corporation Bonaire, 2019, Bonaire Affair, retrieved from http://www.bonaireislandmap.com/bonaireaffair.html

15 Toor, 2010, Landschapspark Rincón – nieuwe mogelijkheden voor inwoner, recreant en natuur, retrieved from https://www.dcbd.nl/document/landschapspark-rincon

16 Van Rossum, L., 2014, herinrichtingsplan mangazina di Rei, retrieved from https://www.dcbd.nl/sites/www.dcbd.nl/files/documents/Herinrichtingsplan%20Mangazina%20di%20Rei.pdf

17 STINAPA website, 2020, retrieved from https://stinapabonaire.org/

18 Central Bureau of Statistics Curacao, 1961, statistical yearbook Netherlands Antilles 1961, retrieved from http://digitallibrary.cbs.cw/statyear/all

19 Bonaire investments NV, 2019, Plantage Bolivia, retrieved from https://www.estatebolivia.com/

20 Trouw, 2020, Op een plantage op Bonaire maken de Kadushi's plats voor dure villa's, retrieved from https://www.trouw.nl/duurzaamheid-natuur/op-een-plantage-op-bonaire-maken-de-kadushi-s-plaats-voor-dure-villa-s~b62ee907/

21 Cormont, A., Verweij, P., Soldaat, L., 2020, Population trend Bonaire, retrieved from https://www.dcbd.nl/population

22 Werbata topographical map, 1911, retrieved from https://www.dcbd.nl/document/werbata-historical-topographical-maps

[23] Mücher, M. & Verweij, P., 2020, concept land use map of interpreted 2x2 m2 resolution satellite imagery dated 2016

[24] IPCC, 2013. Summary for Policymakers. In: Climate Change 2013: The Physical Science Basis. Contribution of Working Group I to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change [Stocker, T.F., D. Qin, G.-K. Plattner, M. Tignor, S.K. Allen, J. Boschung, A. Nauels, Y. Xia, V. Bex and P.M. Midgley (eds.)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA

[25] Verweij, P., Swart, R., van der Sluis, 2018, Klimaat en klimaatverandering, eds. Debrot, A., Henkens, R., Verweij, P., Staat van de natuur van Caribisch Nederland, 2017

[26] Copernicus climate data store, 2019, ERA5 monthly averaged data on single levels from 1979 to present, retrieved from https://doi.org/10.24381/cds.f17050d7

[27] Van der Lely, J., van Beukering, P., Muresan, L., Zambrano Cortes, D., Wolfs, E., Schep, S., 2013, the total economic value of nature on Bonaire, report R-13/01, retrieved from https://www.dcbd.nl/document/total-economic-value-nature-bonaire

[28] CBS, 2019, retrieved from https://www.cbs.nl/en-gb/custom/2019/39/cruiseship-passengers-bonaire-2012-2018

[29] Business Research & Economic Advisors (BREA), 2016, Retrieved from https://antilliaansdagblad.com/bonaire/12884-bonaire-scoort-bij-cruisetoeristen

[30] CBS, 2020, StatLine, retrieved from https://opendata.cbs.nl/statline

[31] CBS, 2020, Population; key figures, retrieved from https://www.cbs.nl/en-gb/figures/detail/37296eng

[32] Government of the Netherlands, 2020, more and more tourists in the Netherlands, retrieved from https://www.government.nl/topics/tourism-and-recreation/strengthening-the-tourism-industry#:~:text=In%202017%2C%20a%20record%20number,1.8%20billion%20by%20that%20year.

[33] Albuquerque, K., McElroy, J., 1992, Caribbean small-island tourism styles and sustainable strategies, Environmental Management, 16(5), pp 619-632

[34] Nunes, G., Silva, N., 2020. Offroad driving policy development, position paper Parke Nacional Aruba

[35] Cormont, A., Verweij, P., Soldaat, L., 2020, Tourists trends on Bonaire, retrieved from https://www.dcbd.nl/monitoring/tourism

[36] Van der Wal, J.T., 2020, personal communication

[37] Slijkerman, D., van der Wal, J., de Vries, P., Verweij, P., 2020, Tracking digital footprints in Bonaire's landscapes – spatial distribution and characterisation of tourists on Bonaire using social media, retrieved from https://www.dcbd.nl/document/tracking-digital-footprints-bonaires-landscapes-spatial-distribution-and-characterisation

[38] Borst, L., de Haas, S., 2005, Hydrological research Bonaire, retrieved from https://www.dcbd.nl/document/hydrological-research-bonaire

[39] Coolen, Q., 2020, private drilling for groundwater with linked or integrated reverse osmosis installations, personal communication

[40] BAAB bv, Dienst Ruimtelijke Ordening Bonaire, 2019, Erosiebestrijding en natuurherstel, retrieved from https://www.dcbd.nl/document/erosiebestrijding-en-natuurherstel

[41] Pourier, S., 2020, salt intrusion as result of overexploitation water wells, personal communication

[42] Van der Geest, M. & Teles, I., 2019. Nexus inerventions for small tropical islands: case study Bonaire, Energy

[43] Ministry of Economic Affairs and Climate Policy, 2019, Integraal Nationaal Energie en Klimaatplan, retrieved from https://www.rijksoverheid.nl/documenten/rapporten/2019/11/01/integraal-nationaal-energie-en-klimaatplan

[44] Verweij, P., Cormont, A., Hoetjes, P., De Meyer, K., Van Bussel, T., Roosenschoon, O., Henkens, R., Schmidt, A. & Janssen, S., 2019. Co-designing a data platform to impact nature policy and management: experiences from the Dutch Caribbean. Environmental Science & Policy 100, pp. 13-20

[45] Debrot, A., Henkens, R., Verweij, P., 2018, Staat van de natuur van Caribisch Nederland 2017

[46] Openbaar Lichaam Bonaire and Dutch Caribbean Biodiversity Database, 2018, Flamingo abundance, retrieved from https://www.dcbd.nl/monitoring/flamingos

[47] Mücher, 2019, erosion risk per catchment on Bonaire

[48] De Bakker, D., van Duyl, F., Perry, C., Meesters, E., 2019, Extreme spatial heterogeneity in carbonate accretion potential on a Caribbean fringing reef linked to local human disturbance gradients, global change biology, retrieved from https://www.dcbd.nl/document/extreme-spatial-heterogeneity-carbonate-accretion-potential-caribbean-fringing-reef-linked

[49] Engel, S., STINAPA, Dutch Caribbean Biodiversity Database, 2019, seagrass species density of the central bay in Lac, Bonaire, retrieved from https://www.dcbd.nl/monitoring/seagrasses

[50] Van der Geest, M. & Slijkerman, D., 2019, Food from the land, Nexus interventions for small tropical islands: case study Bonaire, retrieved from https://www.dcbd.nl/document/nexus-interventions-small-tropical-islands-case-study-bonaire-food-land

[51] Boers, A., 2016, Handbook professional vegetable gardening, retrieved from https://www.dcbd.nl/document/handbook-professional-vegetable-cultivation-bonaire

[52] Wayaka advies, 2018, Basic Book Vegetables and fruits on Bonaire, retrieved from https://www.dcbd.nl/document/basic-book-vegetables-and-fruits-bonaire

[53] Caribisch Netwerk, 2014, Boodschappen op Bonaire ruim 40 procent duurder dan in Nederland, retrieved from https://caribischnetwerk.ntr.nl/2014/02/18/boodschappen-op-bonaire-ruim-40-procent-duurder-dan-in-nederland/

[54] Bogaardt, M.J., R.J. de Jong en C.M. van der Heide, 2015. Voedselzekerheid op Bonaire, St. Eustatius en Saba; Aangrijpingspunten voor de beleidsinzet van het ministerie van Economische Zaken. Wageningen, LEI Wageningen UR (University & Research centre), retrieved from https://edepot.wur.nl/360979

[55] Koomen, A., Makaske, B., van Dorland, G., 2012, Geological map of Bonaire, retrieved from https://www.dcbd.nl/document/geological-map-bonaire. Based on Westerman and Zonneveld, 1956, retrievable from https://www.dcbd.nl/document/historical-geological-map-bonaire-westerman-and-zonneveld and Buisonje, 1956, retrievable from https://www.dcbd.nl/document/historical-geological-map-bonaire-buisonje

[56] Koomen, A., Makaske, B., van Dorland, G., 2012, Soil map of Bonaire, retrieved from https://www.dcbd.nl/document/soil-map-bonaire. Based on Grontmij, 1967, retrievable from https://www.dcbd.nl/document/historical-soil-map-bonaire and Westerman and Zonneveld, 1956, retrievable from https://www.dcbd.nl/document/historical-land-use-and-sample-location-map-bonaire

[57] Verweij, P., van Eupen, M., Mücher, S., 2019, Elevation and bathymetry of Bonaire. Based on Engel, S., 2017, Depths of Lac Bay, retrievable from https://www.dcbd.nl/document/lac-bay-depths-gis and Dienst der Hydrografie, 2018, retrievable from https://www.dcbd.nl/document/bathymetry-survey-bonaire and Meesters, 2014, retrievable from https://www.dcbd.nl/document/digital-elevation-model-bonaire

[58] Dijkman, E., Debrot, A., 1996 landscape ecological vegetation map of Bonaire, retrieved from https://www.dcbd.nl/document/vegetation-map-bonaire. Based on de Freitas, Nijhof, Rojer, Debrot, 2005, retrievable from https://www.dcbd.nl/document/landscape-ecological-vegetation-map-island-bonaire-southern-caribbean

[59] CBS, 2020, census data on neighbourhoods

[60] Charles Eisenstein, 2020, Regenerative agriculture, retrieved from https://www.youtube.com/watch?v=fSEtiixgRJI

[61] Reynolds Oleana, 2020, personal communication

[62] Debrot, D., de Freitas, J., Rojer, A, 1998, Brief Biological Inventory of Bolivia, Bonaire, Netherlands Antilles, retrieved from https://www.dcbd.nl/document/brief-biological-inventory-bolivia-bonaire-netherlands-antilles

[63] Ramsar sites information service, 1980, Het Lac, retrieved from https://rsis.ramsar.org/ris/199

[64] Dutch Caribbean Nature Alliance, 2020, retrieved from https://www.dcnanature.org/bonaire-iba-lac-bay/

[65] Coolen, Q., 2020, a stepwise implementation of erosion control measures for Lac: 1. Deepen natural waterways, 2. construct dams starting at rooi Grandi and working eastwards towards the mangrove centre where there are several small stream crossing the road. Dams can be made from the material from canal deepening. Start 3. reforestation in pace with grey measures and make sure to water the plantings for at least two years intensively as the area is very dry and very saline, personal communication

[66] Wagenaar Hummelink, P., Roos, P., 1968, een natuurwetenschappelijk onderzoek gericht op het behoud van het Lac op Bonaire, retrieved from https://www.dcbd.nl/document/een-natuurwetenschappelijk-onderzoek-gericht-op-het-behoud-van-het-lac-op-bonaire

[67] Cargill, 2016, Making salt in paradise, retrieved from https://www.cargill.com/story/making-salt-in-paradise

[68] Wijffels, R., 2020, Algae grow better on Bonaire, retrieved from https://www.wur.nl/en/article/Algae-grow-better-on-Bonaire.htm and https://youtu.be/Ca_D-594Szs

[69] Domiguez Teles, I., 2020, the salt ponds are commercially a suitable location for algae production, personal communication

[70] Trouw, 2020, retrieved from https://www.trouw.nl/duurzaamheid-natuur/deze-nieuwe-nederlandse-palmboom-is-meteen-een-bedreigde-soort~bfd53a41/

[71] Beautiful Bonaire, 2020, Retrieved from https://www.beautiful-bonaire.nl/natuur/klein-bonaire.php

Wageningen Environmental Research
P.O. Box 47
6700 AA Wageningen
The Netherlands
T +31 (0)317 48 07 00
www.wur.nl/environmental-research

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Wageningen Environmental Research
P.O. Box 47
6700 AB Wageningen
The Netherlands
T +31 (0) 317 48 07 00
www.wur.eu/environmental-research

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