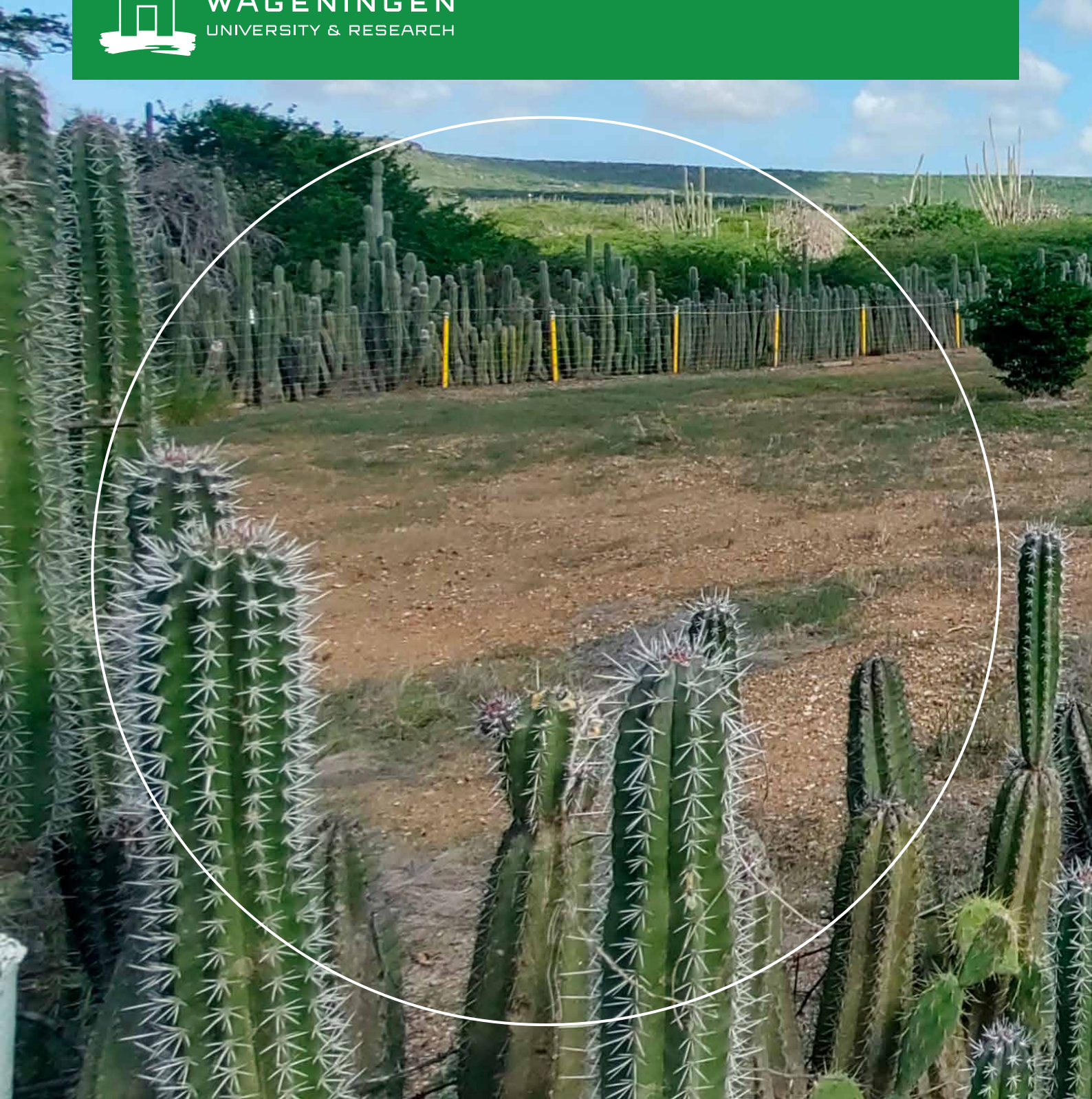


The State of cactus fences and kunukus for nature inclusivity on the island of Bonaire

Jenny Lazebnik, Michiel van Eupen, Peter Verweij



WAGENINGEN
UNIVERSITY & RESEARCH



The State of cactus fences and kunukus for nature inclusivity on the island of Bonaire

Jenny Lazebnik, Michiel van Eupen, Peter Verweij

The authors would like to acknowledge funding from the Wageningen University Knowledge Base programme: KB36 Biodiversity in a Nature Inclusive Society (project number KB36-005-002) - that is supported by finance from the Dutch Ministry of Agriculture, Nature and Food Quality.

Wageningen Environmental Research
Wageningen, February 2022

Reviewed by:
Dr. Bert Lotz, (Wageningen Plant Research)

Approved for publication:
Dr. Sander Janssen (Earth Informatics)

Report 3150
ISSN 1566-7197



WAGENINGEN
UNIVERSITY & RESEARCH

Jenny Lazebnik, Michiel van Eupen, Peter Verweij, 2022. *The State of cactus fences and kunukus for nature inclusivity on the island of Bonaire*. Wageningen, Wageningen Environmental Research, Report 3150. 24 pp.; 4 fig.; 2 tab.; 16 ref.

Agriculture on Bonaire does not support the demand for food on the island, and therefore the people are dependent on expensive food importation. Recently, any Bonairean people abandon their kunukus to take jobs in the urban area in tourism or off-island in the oil industry. Traditionally, a kunuku was used as an agricultural plot for food production for the household. A kunuku would usually have a cactus fence used to contain grazing goats or chickens, or to produce household amounts of sorghum maize, and keep animals out. In order to help restore nature to Bonaire and include it in the daily lives of people, restoration and use of cactus fences on kunukus are being considered as nature inclusive measure. In order to get a better understanding of the current use of kunukus and presence of cactus fences on the island, satellite information and field observations were collected about the state of kunukus and the use of cactus fences. Results show that kunukus are rapidly being abandoned. The predictive accuracy from satellite imagery of active kunukus was high (92.5%). Furthermore, only 4% of the active kunukus have a well-maintained cactus fence. Implications of these findings are discussed with focus on nature inclusiveness and the use of the kunuku as a means to restore a cultural pride, self-sufficiency, local economic diversification and a healthier food culture on Bonaire.

Keywords: Cactus fence, kunuku, agriculture, culture, nature inclusive

The pdf file is free of charge and can be downloaded at <https://doi.org/10.18174/564568> or via the website www.wur.nl/environmental-research (scroll down to Publications – Wageningen Environmental Research reports). Wageningen Environmental Research does not deliver printed versions of the Wageningen Environmental Research reports.

© 2022 Wageningen Environmental Research (an institute under the auspices of the Stichting Wageningen Research), P.O. Box 47, 6700 AA Wageningen, The Netherlands, T +31 (0)317 48 07 00, www.wur.nl/environmental-research. Wageningen Environmental Research is part of Wageningen University & Research.

- Acquisition, duplication and transmission of this publication is permitted with clear acknowledgement of the source.
- Acquisition, duplication and transmission is not permitted for commercial purposes and/or monetary gain.
- Acquisition, duplication and transmission is not permitted of any parts of this publication for which the copyrights clearly rest with other parties and/or are reserved.

Wageningen Environmental Research assumes no liability for any losses resulting from the use of the research results or recommendations in this report.



In 2003 Wageningen Environmental Research implemented the ISO 9001 certified quality management system. Since 2006 Wageningen Environmental Research has been working with the ISO 14001 certified environmental care system. By implementing the ISO 26000 guideline, Wageningen Environmental Research can manage and deliver its social responsibility.

Wageningen Environmental Research Report 3150 | ISSN 1566-7197

Photo cover: Michiel van Eupen en Peter Verweij

Contents

Verification	5
Abstract	7
1 Introduction	9
1.1 Agriculture in Bonaire	9
1.2 What is a Kunuku?	9
1.3 Why bring back agriculture in kunukus?	10
1.3.1 To reduce the dependency on expensive imports and diversify the local economy	10
1.3.2 To stimulate a healthier population	10
1.3.3 To stimulate a culture of self-sufficiency and local pride	10
1.4 Why the cactus fence?	10
2 What is the current and historic use of the kunukus and cactus fences on Bonaire?	11
2.1 Satellite data analysis and historical maps	11
2.1.1 Results from historical maps and satellite data	12
2.2 Case study: One kunuku over time	13
2.3 Methodology field observations	14
2.3.1 Determining activity from satellite imagery and state of fences	14
2.4 Results from the field	15
2.4.1 Predictions of location and status of kunukus	15
2.4.2 Assessment of presence and state of cactus fences	16
2.4.3 Examples of cactus fences assessed in 'good' state	18
2.4.4 Examples of cactus fences in 'partial' state	18
2.4.5 Examples of cactus fences in 'poor' state:	19
3 Conclusions and discussion	20
3.1 Conclusions from the experimental findings	20
3.2 Future possibilities and options to support kunuku use	20
3.2.1 Cactus fences	20
3.2.2 New types of agriculture and production centres	20
References	23

Verification

Report: 3150

Project number: KB36-005-002

Wageningen Environmental Research (WENR) values the quality of our end products greatly. A review of the reports on scientific quality by a reviewer is a standard part of our quality policy.

Approved reviewer who stated the appraisal,

position: team leader applied ecology

name: Dr. Bert Lotz

date: 28 January 2022

Approved team leader responsible for the contents,

name: Dr. Sander Janssen

date: 14 January 2022

Abstract

Agriculture on Bonaire does not support the demand for food on the island, and therefore the people are dependent on expensive food importation. Recently, any Bonairean people abandon their kunukus to take jobs in the urban area in tourism or off-island in the oil industry. Traditionally, a kunuku was used as an agricultural plot for food production for the household. A kunuku would usually have a cactus fence used to contain grazing goats or chickens, or to produce household amounts of sorghum maize, and keep animals out. In order to help restore nature to Bonaire and include it in the daily lives of people, restoration and use of cactus fences on kunukus are being considered as nature inclusive measure. In order to get a better understanding of the current use of kunukus and presence of cactus fences on the island, satellite information and field observations were collected about the state of kunukus and the use of cactus fences. Results show that kunukus are rapidly being abandoned. The predictive accuracy from satellite imagery of active kunukus was high (92.5%). Furthermore, only 4% of the active kunukus have a well-maintained cactus fence. Implications of these findings are discussed with focus on nature inclusiveness and the use of the kunuku as a means to restore a cultural pride, self-sufficiency, local economic diversification and a healthier food culture on Bonaire.

1 Introduction

1.1 Agriculture in Bonaire

Bonaire is a small and very dry tropical island where agriculture has become quite difficult due to drought conditions (Lotz et al., 2020). A lot of rain water evaporates before it can sink into the soil. If rainwater does infiltrate the soil, because of the soil's dry depleted quality, it easily seeps away into underground cracks and fissures where it flows back into the sea. The freshwater wells are limited, and salt from the sea, infiltrates the wells and becomes unusable for irrigation.

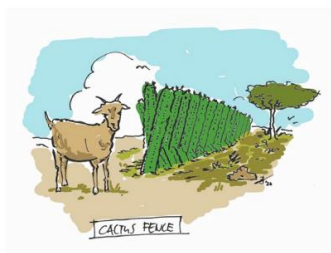
Agriculture on Bonaire does not support the demand for food on the island, and therefore the people are dependent on expensive food importation (Bogaardt et al., 2015). Erosion and climate change are also continued threats to the island's bioeconomy and biodiversity. It is expected that the average temperature will rise 1.4 degrees Celsius. This is a development that can already be observed from the monthly temperature average of the past forty years. For this reason, nature-inclusive solutions in Bonaire should include drought-compliant options which could support agricultural innovation and restore some of the native landscapes. This report focuses on one of these nature inclusive options: the cactus fences. More specifically those which are found surrounding a Bonairean kunuku.

This report is part of a larger project that describes a vision for 'nature inclusiveness' in Bonaire. Nature inclusiveness is a concept which instead of separating or protecting nature in reserves, integrates nature in with the daily lives of people across different sectors. Some of the ideas for nature inclusive measures are shown below:

EXAMPLES OF NATURE INCLUSIVE MEASURES

PLANTING CACTUS FENCES

Natural protection from roaming livestock, appealing landscape, attracts birds and small reptiles.



ROOFTOP WATER HARVESTING

Use fresh water for drinking or watering plants, less expensive than desalination.



GREENING GARDENS

Trees create shade and increase living area for butterflies and birds.



REVEGETATION

Decreases land wash-off, keeps more water in the soil while providing shade.



1.2 What is a Kunuku?

Traditionally, a kunuku was used as an agricultural plot. It would usually be used to contain grazing goats or chickens, or to produce household amounts of sorghum maize. Historically, these kunukus were separated by cactus fences. These fences consisting of living cactus plants, were pruned into alignment by removing the unwanted arms. After the needles were removed from the cacti, they could be used to feed the goats or chickens.

Since the 1930's Bonaireans started leaving the island to work in the oil industry on Curacao and Aruba, thus leaving many kunukus abandoned. In 1963 scuba diving was becoming popular, and tourism became much more lucrative. In 2010 Bonaire became a special municipality of the Netherlands, and therefore much easier for Dutch people to visit. Since the tourism industry had become so lucrative, and farming being very labour intensive, many Bonairean people abandoned their kunukus to take jobs in the urban areas or off-island.

1.3 Why bring back agriculture in kunukus?

The return of (not necessarily traditional) kunuku use in Bonaire could be seen as having three main aims:

1.3.1 To reduce the dependency on expensive imports and diversify the local economy

Since the local agricultural production has basically been outsourced to off-island, the economy has also become more singularly dependant on tourism. With stimulation of the kunukus for agricultural use, the economy could be expanded to produce different kinds of commodities that are possible to grow in the local climate and conditions of the kunukus (Lotz et al., 2020). Stimulating local agricultural businesses could diversify local economy and provide security against single points of failure in the income streams (Verweij et al., 2020).

1.3.2 To stimulate a healthier population

Since the tourism industry has become the main source of income, most locals work in cities, and the source of food (to locals and tourists) is at the supermarket. Because of the dependency on importation. Since fresh fruits and vegetables are often difficult to import, these fresh and healthy foods are the most expensive and harder to come by (Bogaardt et al., 2015). This triggers an unhealthy culture, since most people are not used to eating fresh and healthy food anymore. Stews and deep frying are the prevailing ways to prepare food, and vegetables are hardly used (Verweij et al., 2020). In Bonaire 30% of the residents are obese, and 60% are overweight (CBS, 2020). The health and food culture are losing footing due to the dependence on imported food.

1.3.3 To stimulate a culture of self-sufficiency and local pride

Stimulating the use of household kunukus for local production of healthy food would increase the self-sufficiency of the island households (Mangazina di Rei, 2021). Introducing the knowledge of growing your own food could also be part of early education, and a way to stimulate small business and entrepreneurship. Stimulating self-sufficiency and a culture of pride in the local landscape could give the people a sense of community and belonging (OLB, 2021). Using small scale kunukus as farms could be a way to support a healthy lifestyle (LVV, 2021), which in itself is another way to boost the personal pride and morale.

1.4 Why the cactus fence?

Historically, these have been used to delineate the kunuku perimeter, but also used as food for the goats and livestock. The vegetation also provides shade, and stimulates local biodiversity. Cactus fences are also very effective as household security fences against trespassers.

2 What is the current and historic use of the kunukus and cactus fences on Bonaire?

In order to get a better understanding of the current land of kunukus and presence of cactus fences on the island, researchers from Wageningen Environmental Research (WENR) collected satellite information and field observations about the state of kunukus and the use of cactus fences the island of Bonaire. Two main questions were addressed:

1. *Can we validate the locations of the kunukus and their status as active or non-active based on the interpreted satellite imagery?*

In other words, how accurate is our prediction of the ground truth about kunuku location and status

2. *How has the activity of kunukus changed with time?*

Describing the trends by using historical paper maps and satellite images of kunukus

3. *Of the currently active kunukus, what is the state of cactus fences?*

Without practical experience, cactus fences were close to indistinguishable in the satellite data, so a sampling and assessment of the state of the fences was conducted.

2.1 Satellite data analysis and historical maps

As a starting point, the location of kunukus on Bonaire was estimated based on digitisation of fields from a historical paper map from 1952 (Roefs and van Eupen, 2021, Westerman & Zonneveld, 1956) and digitisation of Google Earth satellite imagery of 2003 and 2019 (Jailani et al., 2020). See (Figure 1) for details. In the satellite images, fields were interpreted as being 'active' when borders could be distinguished between field and neighbouring area and that fields were barren in contrast to the borders and/or neighbouring area.

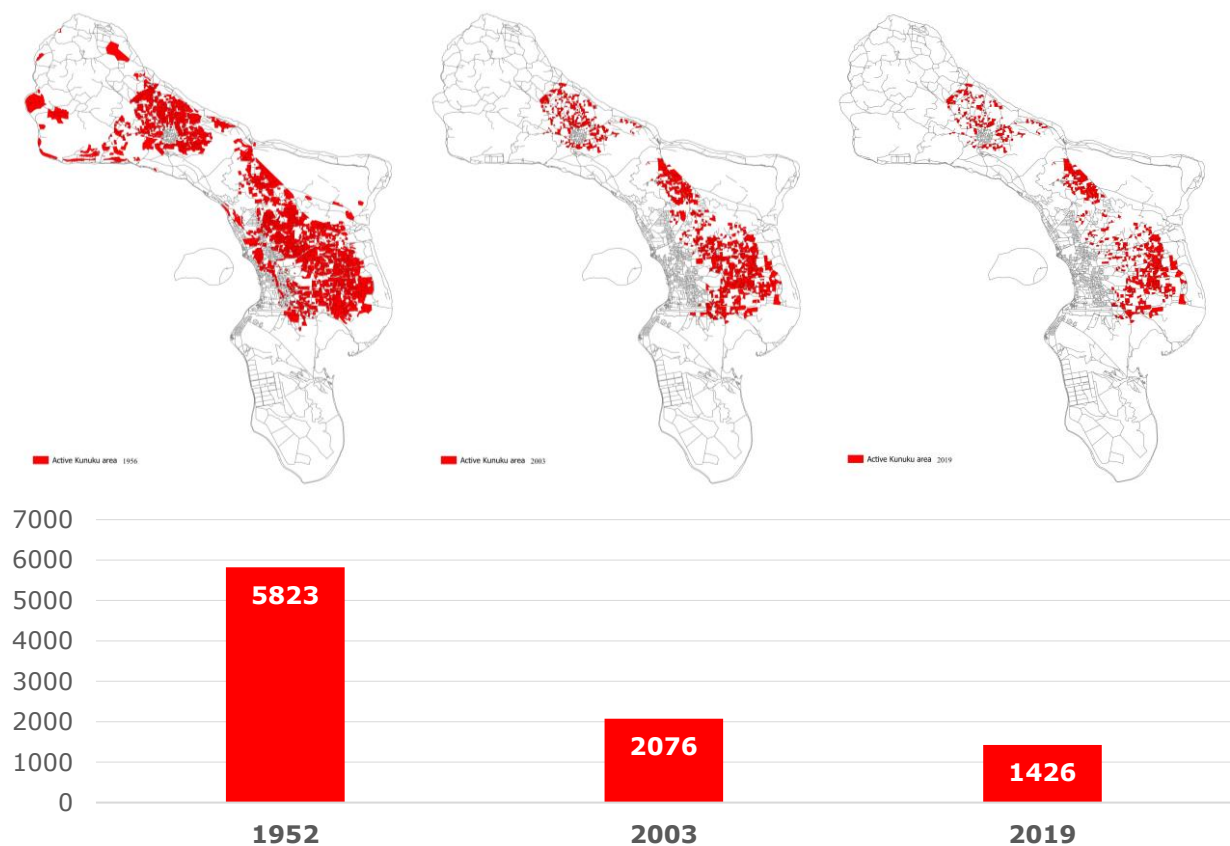


Figure 1 Estimated active kunuku area Bonaire in 1952 (left), 2003 (middle), and 2019 (right), based on historical satellite imagery.

2.1.1 Results from historical maps and satellite data

It is clear from historical maps and satellite data that between 1952 and 2019 76% of the total kunuku area was lost, but that the average parcel size stayed the same (around 2.2-2.3 ha). In 1952, 2524 kunukus were identified totalling 5823 ha. In 2003, 947 active kunukus, with a total area of 2076 ha were estimated based on the satellite data. An addition 151 inactive kunukus were estimated in Rincon (base on map 2003, parcels were visible, but clearly not in use: natural vegetation is visible and overgrowth is seen in the images (see also the case study of a kunuku). In 2019, 624 active kunukus were estimated, with a total area of 1426 ha (See Table 1).

Table 1 Overview of active used area and number of Kunukus between 1952 and 2019.

Period	Number of Active kunuku parcels			Active kunuku area (ha)		
	Parcels	Lost since 1952	Average lost since 1952 (nr/yr)	Total agricultural area	Loss since 1952	Estimated loss in period (ha /yr)
1952	2524	<i>n.a.</i>	<i>n.a.</i>	5823	<i>n.a.</i>	<i>n.a.</i>
2003	947	1577	19	2076	3747	73
2019	624	1900	9	1426	4397	66

Based on the estimated amount of active kunukus from the historical maps, the activity of kunukus was reduced by 33% from 2003 until 2019. Because of this trend towards kunuku abandonment, it was hypothesized that even fewer kunukus would still be active upon visitation in 2021.

2.2 Case study: One kunuku over time

In order to showcase the progression of vegetation growth, and the distinguishability of a cactus fence on a Bonairean kunuku we have used a sample location and collected images from satellites over the course of about 20 years. Below you see images from the same place in 2003, 2014, 2016, 2018 and 2021 (Figure 2). You can also notice the resolution quality and coloration differs between the satellite sources. In 2002 the kunuku was in use (Figure 2A) agriculturally, but no housing or buildings are present. Between 2002 and 2012 the area is very green (Figure 2B) apparently has gradually grown over, signs of active use are fewer and cactus fence becomes less distinguishable. In 2016 (Figure 2C) parts of the plot start to get cleared for use and the cactus fence becomes much clearer to delineate. In 2018 (Figure 2D) a house is built on the kunuku, more ground is cleared but also more of the plot starts to show signs of vegetation on the previously cleared space. In 2021 (Figure 2E) the kunuku stays in use and not much has changes on the grounds since 2018, the vegetative growth matures but the fence remains easy to discern. The image from Figure 2F is taken from a drone to show the difference in resolution in the plot in 2020.

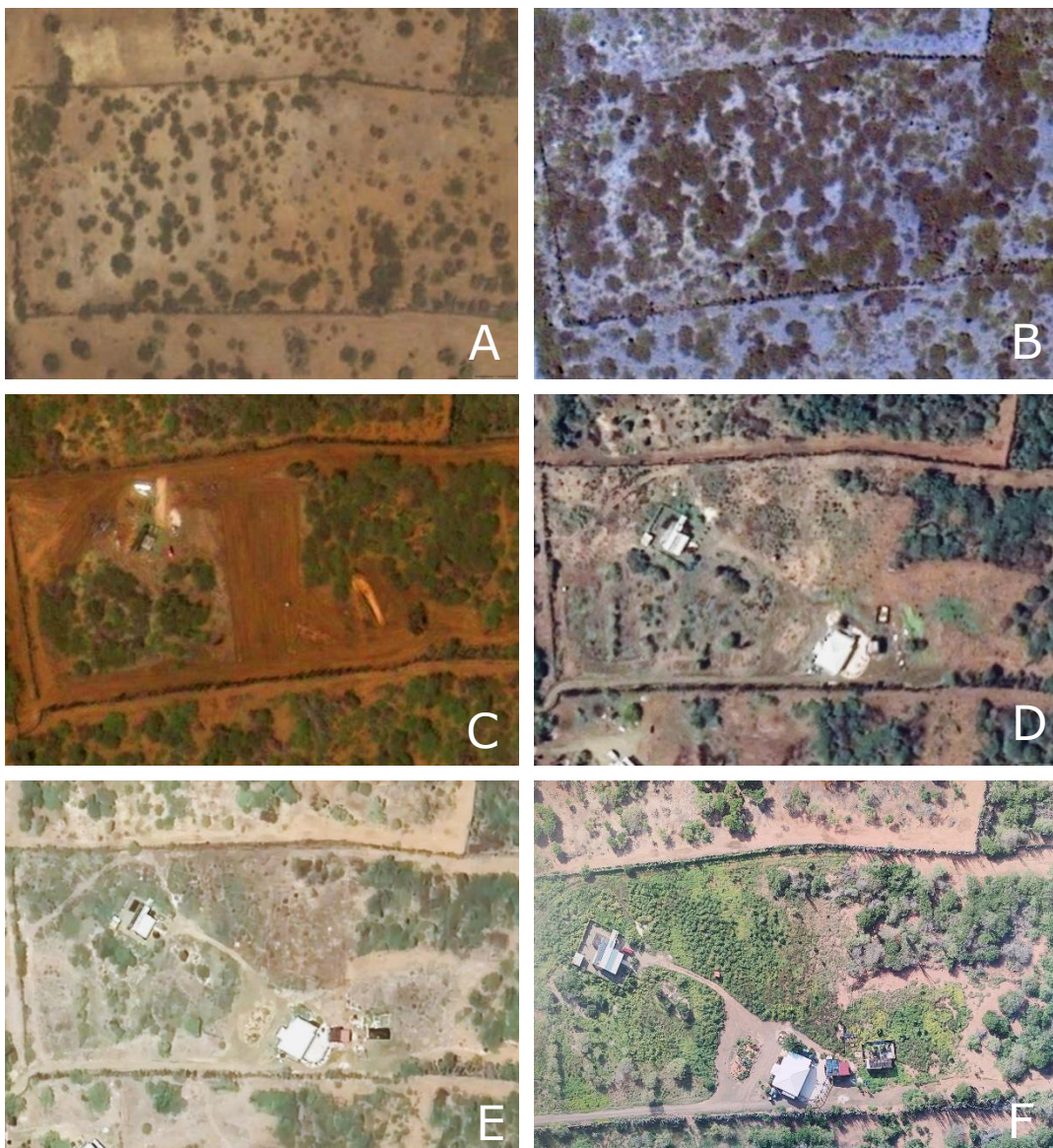


Figure 2 An example kunuku location in Bonaire (12.144072532308728, -68.2419902276383) throughout several years, A: 2003, Google Earth; B: 2014, Pleiades 50cm resolution; C: 2016, Bing Aerial; D: 2018, Google Earth; E: 2021, Google Earth; F: 2021, drone photo (circa 2020).

2.3 Methodology field observations

In order to check the accuracy of the estimations from satellite images, and assess the presence and state of the cactus fences, WENR researchers conducted field work on a random sampling of kunukus.

To decide which kunukus to visit in person, a random sampling was conducted done by features in QGIS (function by Santos, A, 2021). Two different random samplings were done:

1. From the plots estimated to be 'active' from the 2019 satellite images: 59 random sites were chosen.
2. From the plots estimated 'active' or 'non-active' from 2019 satellite images: 60 sites were chosen.

The bias towards active kunuku plots was intentional as active sites were assumed to be more likely to have cactus fences. In total 119 plots were selected to be visited, of those 3 were duplicates leaving 116 planned kunukus for visitation (See map of selected active and inactive kunukus Figure 3).

2.3.1 Determining activity from satellite imagery and state of fences

Clues such as crop (sorghum) cultivation, goats, or any signs of up-keep activity were used to determine if a site was deemed and expected to be 'active'. The absence of these signs, or the use of the land for garbage was deemed 'non-active'.

The following categories used in determining the state of the cactus fences (see example photos below):

Good- well maintained and visible cactus fence with few to no gaps

Partial- overgrown, outgrown or several gaps in fence

Poor- No fence or iron fence only- cacti barely visible or not maintained

The green and red dots in Figure 3 were visited and checked for active or inactive status. The presence and state of the cactus fences was also checked at each site. The highlighted light red or light green represent the expected state if a kunuku as active or inactive based on the 2019 satellite data imagery.

2.4 Results from the field

2.4.1 Predictions of location and status of kunukus

According to the satellite images, 624 kunukus were determined as 'active', of these 116 kunukus we selected to visit. Of the 116 selected plots, only 89 were accessible (reachable by vehicle/or on foot). Some kunukus could not be accessed behind a private field or lacked an accessible roadway.

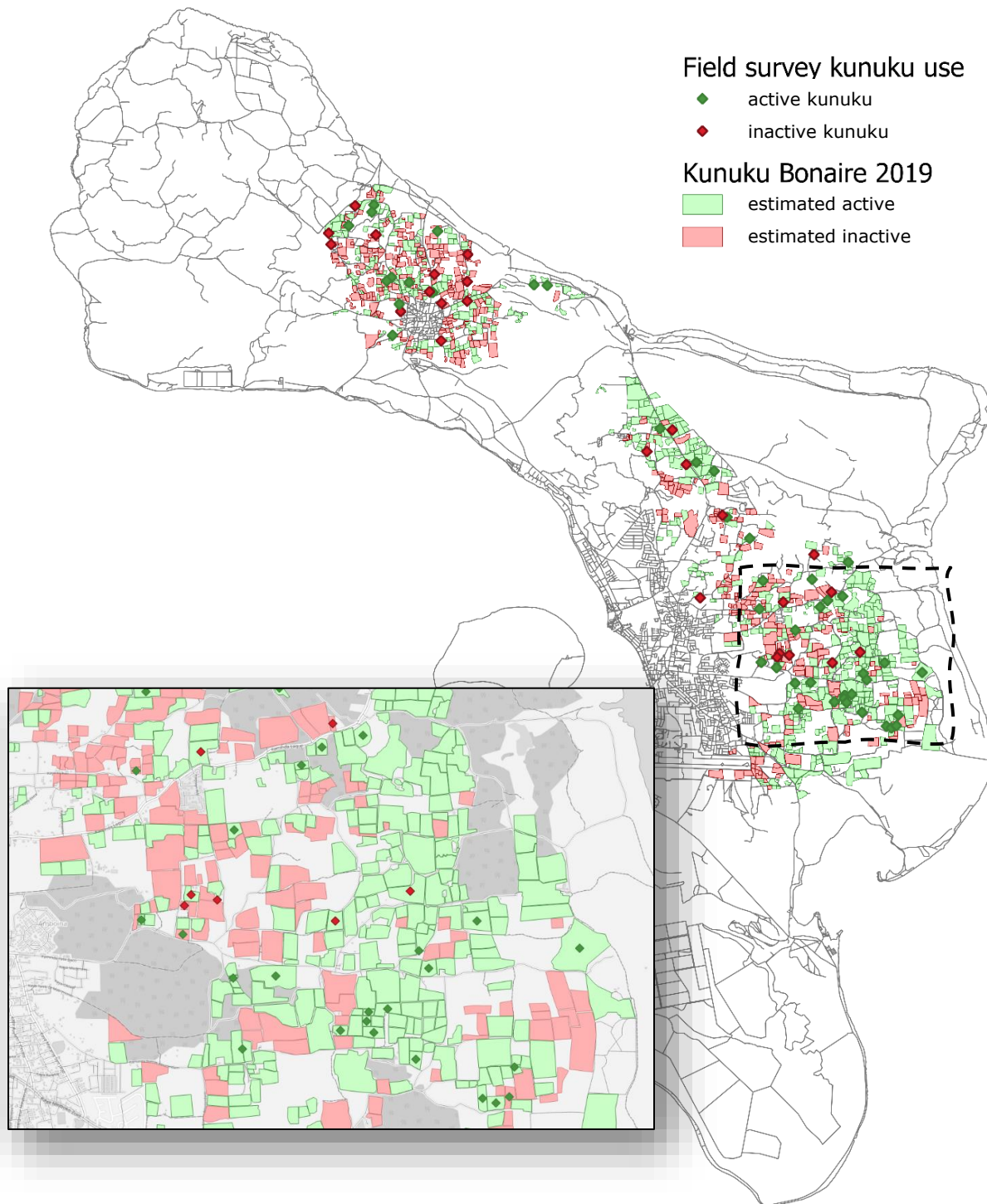


Figure 3 Kunuku plots in Bonaire estimated to be active (green fields) and inactive (red fields) from 2019 satellite imagery, and the physically visited kunukus assessed as active (green diamonds) and inactive (red diamonds) in 2021.

The 'active' use status of kunukus was overestimated, yet the accuracy of estimating an active kunuku was still 92.5%. It was more difficult to estimate an inactive kunuku from the satellite imagery, this was possible with an accuracy of only 65% (See Table 2). Upon visitation only 71 were active from the 89 visited kunukus.

Table 2 Overview of estimated number and ground truth number of active and inactive Kunukus.

Kunuku status	Estimated	Active on visitation	Inactive on visitation	Estimation accuracy of kunuku from satellite imagery
Active	69	64	5	92.5%
Inactive	20	7	13	65%
Total	89	71	18	

2.4.2 Assessment of presence and state of cactus fences

Of the visited active kunukus with cactus fences, 80% of the fences were assessed as 'poor' or very poorly maintained. Of the 89 visited kunukus, 14 were categorized as 'partial' cactus fences (16%) and only 4 van de 89 fields (4%) were considered having a 'good' cactus fence, see map Figure 4. Good fences were detectable easily on satellite photos after this experience. See Figure 2C-F for example of satellite views of a 'good' cactus fence versus the overgrown 'partial' fence (Figure 2B).

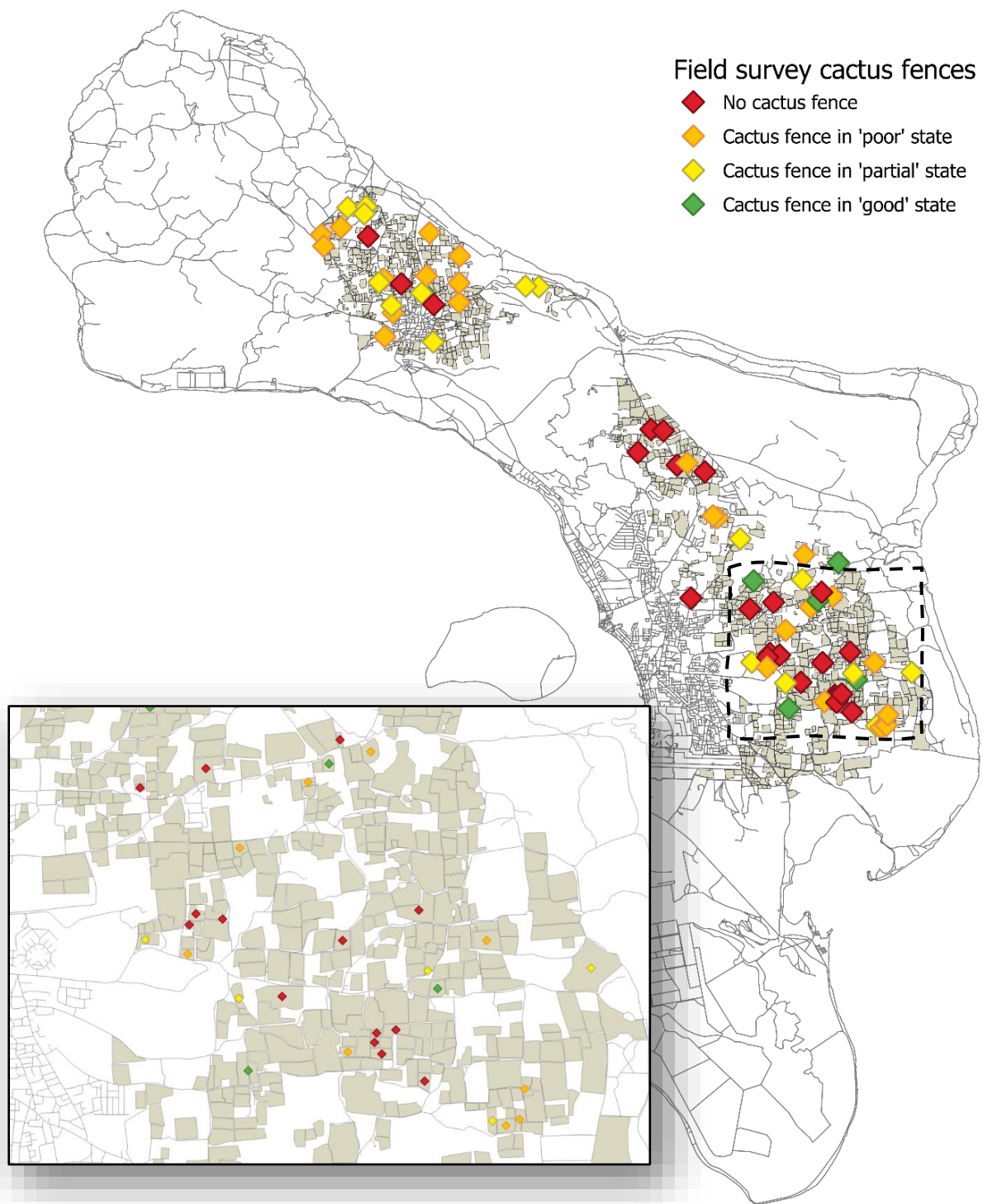


Figure 4 Map showing the state of cactus fences on visited active kunukus.

2.4.3 Examples of cactus fences assessed in 'good' state



2.4.4 Examples of cactus fences in 'partial' state



2.4.5 Examples of cactus fences in 'poor' state



3 Conclusions and discussion

3.1 Conclusions from the experimental findings

Even fewer kunukus were active than what was estimated based on the 2019 satellite images, yet the prediction of kunuku being active was fairly good (92.5%). Therefore, it is likely that using high resolution satellite imagery or arial photos is possible for monitoring kunuku active status in the future. Inactive status of a kunuku however, is harder to predict using satellite imagery techniques. The vegetation is difficult to discern and therefore plot areas are harder to distinguish from one another.

Using the case study example however, we were able to see that a plot left alone can clearly become overgrown within a period of 10 years. Within 10 more years the kunuku could be brought back to use agriculturally including native biodiversity, with active attention, clearing and planting. This example brings to light a follow-up hypothesis that if a kunuku becomes inhabited than the cactus fences and landscape becomes clearly better looked after.

Although active status of the kunuku can be relatively well estimated via arial photographs at high resolution, the state (poor, partial or good) of cactus fence state is less accurately estimated. Upon visitation, it became clear that most cactus fences were in a poor state (80%). Since overgrowth makes it difficult to distinguish the fenced areas from shrub patches. Only 4% of the cactus fences were well maintained, fences in a 'good' state were the best distinguishable from the satellite images.

This could mean that stimulating cactus fences as a biodiversity or nature inclusive measure on Bonaire will be a difficult task. As most of the day of an average Bonairean currently is spent in urban areas, and many of the are kunukus abandoned: stimulating cactus fences does not seem to be a likely option unless agriculture on kunukus is more actively practiced. Inhabited kunukus were observed to have better maintained (cactus) fences. This could be a possible future research question/activity to explore as a follow up to this study.

3.2 Future possibilities and options to support kunuku use

3.2.1 Cactus fences

Cactus fences are an esthetic historic and cultural landscape element. They are a positive nature inclusive measure to prevent erosion, increase water infiltration and habitat and a source of food though pruning in the dry season (Verweij, 2020). They are not however, necessarily the most practical nature inclusive measure. They are difficult and costly to maintain, both in time and labour. Replanting cost can be as much as \$40/meter (BonBerde, 2021; Beukeboom, 2021). They are also hard to use without combination of another type of fence- (ex. Iron), since gaps may occur in the natural hedge formation. Iron fences alone however also rust out and need frequent changing and/or maintenance. There is no perfect solution. In urban areas, cactus fences are more popular because they are used as prevention against break-ins, and used for privacy. Since maintaining these fences are time consuming and costly, using cactus fences more extensively as a nature inclusive measure on Bonaire must therefore go hand in hand with the return of agricultural usage on the kunukus.

3.2.2 New types of agriculture and production centres

Stimulation of cactus fence use might be easier done if the structure of the fences did not necessarily need to be so tight as to contain animals. Plant based agricultural solutions can be optimal for the growth of the cactus fences and may also be more forgiving in terms of maintenance. This could mean the introduction of agroforestry. Fruits in combination with sorghum for example.



Greenhouse use, or agricultural centers could also be useful, to create more space for growing leafy crops which may be able to grow on collected rainwater.



Vegetable gardening also helps to some extent to cut down on household food expenditure. It is also a source of fresh nutrients and part of a healthy diet which is at risk of being overlooked if the main diet is not locally available. However, these types of initiatives and entrepreneurship need to be greatly upscaled or stimulated to lower the dependency on imported food. Growing food is also a valuable education tool that can be used as a part of local school programs (Almerkerk & Pourier, 2018).



Desalination plants to produce water via reverse osmosis are costly, and water wells are becoming increasingly scarce due to intensive use. Integrating rainwater collection as part of the cultural practice could also improve the agricultural practice. Creating places where the rainwater could flow into a shared water storage system could help restore some of the landscape from the drought patterns caused by fresh water absorption, salinization and evaporation. Cactus fences around vegetable beds may also help to absorb and store some of the ground moisture, if more attention was given to the landscape properties on future nature inclusive kunukus.

The cactus fences, kunukus and local gardens are part of the Bonairean cultural heritage. Encouraging the active use of the kunukus and attention to the landscape elements (like the cactus fences, trees and other green elements) can help bring the island back to life in places where it has become abandoned. The focus of education on what can be created locally can also help engage young people to learn about growing food, and eating well.

By changing the type of agricultural practices to stimulate kunuku use on Bonaire, nature inclusivity, and self-reliance for food production is possible. Encouraging new types of agriculture to the kunukus can restore green infrastructure, diversify the local economy, bring back some of the local cultural heritage and pride, and use these for education programs.

References

- Almenkerk van, J. & Pourier, S., 2018, POP Bonaire - rural development program 2014-2018, in Bionews, 13, retrieved from: <https://www.dcnanature.org/wp-content/uploads/2018/08/BioNews-2018-13-POPbonaire.pdf>
- Beukeboom, E., 2021, personal communication on September 26th 2021
- 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>
- BonBerde, personal communication Quirijn Coolen on September 20th 2021
- CBS, 2020, StatLine, retrieved from <https://opendata.cbs.nl/statline>
- Eupen van, M., Verweij, P., 2021, Kunuku activity and cactus fence observations, retrieved from <https://www.dcbd.nl/document/kunuku-activity-and-cactus-fence-observations-on-January-2022>
- Jailani, Z., van Eupen, M., Verweij, P.J.F.M., 2020, Agricultural fields (Kunuku) Bonaire, <https://www.dcbd.nl/document/agricultural-fields-kunuku-bonaire>
- Lotz L.A.P., A.O. Debrot, F. Neijenhuis, C. Stanghellini en R.E.E. Jongschaap, 2020. Ontwikkelingsmogelijkheden voor de landbouw in Caribisch Nederland, Wageningen University & Research, Rapport WPR-1026. 46 blz.; 9 fig.; 1 tab.; 66 ref. <https://doi.org/10.18174/536176>
- LVV, 2021, personal communication Maurice Adriaens on September 21st 2021
- Mangazina di Rei, 2021, personal communication Danilo Christiaan on September 27th 2021
- OLB, 2021, personal communication Nolly Oleana on September 17th 2021
- Peter Verweij, Anouk Cormont, Jeanne Nel, Bertram de Rooij, Lawrence Jones-Walters, Diana Slijkerman, Katrine Soma, Michiel van Eupen, 2020, A nature inclusive vision for Bonaire in 2050. Report 3023 ISSN 1566-7197
- Roefs, B., van Eupen, M., 2021, Kunuku fields Bonaire 1956, retrieved from <https://www.dcbd.nl/document/kunuku-fields-bonaire-1956-on-January-2022>
- Santos, Alex. Retrieved from: QGIS Python Plugins Repository Sample By Features. <https://plugins.qgis.org/plugins/SampleByFeatures/>
- Verweij, P., Cormont, A., Nel, J., Rooij, B. de, Jones-Walters, L., Slijkerman, D., Soma, K., van Eupen, M. 2020, Bonaire 2050, a nature inclusive vision, <https://www.dcbd.nl/document/bonaire-2050-nature-inclusive-vision>
- Westerman, J.H., Zonneveld, J.I.S. 1956, Map of Bonaire, <https://www.dcbd.nl/document/historical-land-capability-map-bonaire>

Wageningen Environmental Research
P.O. Box 47
6700 AA Wageningen
The Netherlands
T 0317 48 07 00
wur.eu/environmental-research

Report 3150
ISSN 1566-7197



The mission of Wageningen University & Research is "To explore the potential of nature to improve the quality of life". Under the banner Wageningen University & Research, Wageningen University and the specialised research institutes of the Wageningen Research Foundation have joined forces in contributing to finding solutions to important questions in the domain of healthy food and living environment. With its roughly 30 branches, 6,800 employees (6,000 fte) and 12,900 students, Wageningen University & Research is one of the leading organisations in its domain. The unique Wageningen approach lies in its integrated approach to issues and the collaboration between different disciplines.

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



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

Report 3150
ISSN 1566-7197

The mission of Wageningen University & Research is "To explore the potential of nature to improve the quality of life". Under the banner Wageningen University & Research, Wageningen University and the specialised research institutes of the Wageningen Research Foundation have joined forces in contributing to finding solutions to important questions in the domain of healthy food and living environment. With its roughly 30 branches, 6,800 employees (6,000 fte) and 12,900 students, Wageningen University & Research is one of the leading organisations in its domain. The unique Wageningen approach lies in its integrated approach to issues and the collaboration between different disciplines.

