



# **Nexus interventions for small tropical islands: case study Bonaire**

Food from the Land

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Like most small tropical islands, Bonaire is largely dependent on imported food. This results in high food prices due to import taxes and transport costs, and high vulnerability towards price fluctuations and global developments, which both present major risks to food security. With many inhabitants living on or below the poverty line, low incomes translate into eating cheap unhealthy food, often causing health issues. While 25% of Bonaire's surface consists of rural areas suitable for on-land food production, current practices of agriculture are small scale, mainly due to small domestic markets and limited access to freshwater, electricity, human capacity and know-how, while the widely used practice of extensive husbandry results in suboptimal yield and severe grazing-induced erosion issues. Sustainable development of agriculture and husbandry on Bonaire thus provides a great opportunity to increase food security, but requires a holistic (nexus) approach that accounts for the local socio-economic setting and the interlinkages between the water, food, energy and ecosystem domains, to identify trade-offs and seek for synergies among these domains. Several nexus interventions are presented that will aid sustainable development of the agricultural and livestock sector, while simultaneously contributing to water, energy, ecosystem and nutrition security. Identified key nexus interventions are: strong policy aimed at facilitation of fenced livestock keeping, water-saving agriculture, decentralized solar power, development of an agro-business and knowledge centre, and development of educational programmes on sustainable agriculture and healthy diet.

Current state	Desired state	Challenge	Nexus intervention
<p>99% of consumed food is imported</p> <p>Unhealthy diet pattern due to relatively high price of healthy fresh food and low awareness of health-risks associated with unhealthy diet</p> <p>High rate of diet-related chronic diseases (i.e. obesities, diabetes)</p> <p>Lack of implementation of food policy by local government</p> <p>Entrepreneurship in food production sector not highly developed</p> <p>Poor transport infrastructure</p> <p>Theft and limited access to infrastructure, freshwater and electricity limit agricultural development in rural area</p> <p>Practice of inefficient extensive husbandry (i.e. free-roaming goats) with suboptimal yield and severe impact on natural habitat due to grazing-induced erosion</p>	<p>A sustainable resilient food system that provides year-round access to affordable, safe, sufficient, and nutritious food, and that contributes to healthier nutrition</p>	<p>Stakeholder involvement</p> <p>Shared fact finding</p> <p>Little financial means to improve transport infrastructure and access to freshwater, electricity, agro-technology, knowledge and human capacity</p> <p>Increasing poverty, which will make it difficult to change unhealthy diet patterns</p> <p>Environmental change (e.g. changing rainfall patterns, sea-level rise, salinization, increasing risk of natural disasters)</p> <p>Low public support for the provision of subsidies to explore the potential of saline agriculture</p>	<p>Strong policy aimed at creating the enabling environment for a sustainable local food production system through facilitation of:</p> <ul style="list-style-type: none"> <li>• fenced livestock keeping</li> <li>• allocation of (treated waste) water towards agriculture</li> <li>• restoration of dams and husbandry allocation of collected rainwater towards agriculture</li> <li>• decentralized solar power in rural area by providing green loans</li> <li>• development of an agro-business and knowledge centre</li> <li>• access to innovative agro-technology</li> <li>• pilot studies to explore feasibility of using innovative sustainable agricultural technologies (e.g. saline agriculture, hydroponics, reverse-osmose systems, crop selection)</li> <li>• Agricultural diversification to strengthen resilience and productive capacities</li> <li>• Upscaling of existing sustainable agriculture</li> <li>• quality food production and local branding</li> <li>• educational programmes for youth on sustainable agriculture and healthy food consumption</li> <li>• internships and apprenticeships in the agricultural sector</li> <li>• increased utilization of locally produced food</li> </ul>

## INTRODUCTION

**Food security and nutrition is a known challenge for many small tropical islands.** On small tropical islands, local food production is often constrained by the arid climate, limited availability of resources (e.g. fertile land, freshwater) and infrastructure (e.g. inadequate ports, roads, storage facilities), small domestic markets, geographical remoteness resulting in very high logistic costs that undermine export led development, and the dominance of other economic sectors, most notable tourism. As such, small tropical islands typically depend on import for their food supply, and Bonaire is no exception. Although this dependence on imported food provides some form of food security, it also creates numerous problems with regard to food security. These problems include relatively high food prices due to import taxes and high transport costs, high vulnerability towards price fluctuations and global developments, significant levels of food loss and waste, environmental and natural resource degradation, and growing malnutrition and public health costs due to the emergence of and preference for more energy dense and convenient processed foods (FAO 2017).

## CURRENT STATE, TRENDS & DRIVERS OF CHANGE

**On Bonaire, local food production is small-scale and comprises fisheries (discussed in more detail in the factsheet “Food from the Oceans”), culturing of fruits, vegetables and cattle feed, and animal husbandry.** Although agriculture forms a large part of the cultural heritage on Bonaire, less than 1% of the economically active population work full-time in the agricultural and livestock sectors (Openbaar Lichaam Bonaire 2014, p.4). The small-scale character of the agricultural sector on Bonaire can be attributed to the arid climate, limited infrastructure, limited human capacity, and limited availability of freshwater: groundwater is mainly brackish, and unsuitable for irrigation of most crops, while watersheds only contain water after heavy rainfall which is restricted to the wet season. Grazing is an additional limitation of crop production. Horticulture for vegetables is only possible in greenhouses, as crops that are grown on open fields will be grazed by parrots, insects, and free-roaming livestock (mainly goats) and suffer from intense sunlight. Greenhouses made of gauze are especially suitable for horticulture, as they allow for regulation of sunlight and as they allow for wind to enter to prevent heating up, while also keeping out insects and other herbivores, but their purchase and maintenance do require additional investments.

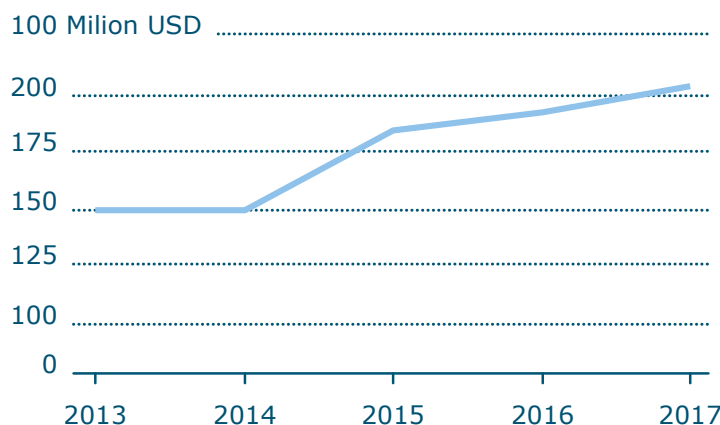
Moreover, the domestic market is too small to provide significant scale economies, while limited export volumes and distance to larger markets, lead to high freight cost and reduced competitiveness.

**Bonaire is almost fully dependent on import for its food supply.** Fifty years ago, Bonaireans provided for a large part in their own food supply and exported production to Curaçao. However, over the years the self-sufficiency household level has reduced considerably, mainly due to increased welfare, the rise of the status of office work, urbanisation, and globalisation, which made it easier (and cheaper) to buy imported food than to grow it yourself (Bogaardt et al., 2015). The lack of priority by policy makers to develop the agricultural sector, also contributed to the current reliance on imported food. However, small-scale agriculture and animal husbandry still have an important socio-economic function for many people, as they generate an income in addition to their salary or pension (Bogaardt et al., 2015).

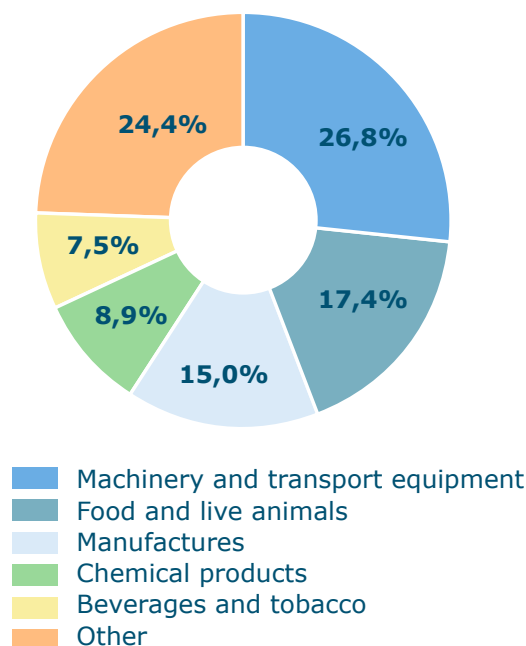
**Current agricultural practices are extensive, with both investments and profits being low.** Local agriculture provides a small part of the market’s need for fruit and vegetables, while the livestock sector provides eggs, goat and sheep meat. Only for eggs, Bonaire is self-sufficient (Openbaar Lichaam Bonaire 2014, p.4). As a consequence, on Bonaire, it is estimated that 99% of all daily food products are imported (Openbaar Lichaam Bonaire 2014, p.12). This high reliance on import is reflected by the island’s annual trade deficit, which increased to 202 million US dollars in 2017 (see Fig. 1). In 2017, Bonaire imported 37 million US dollars’ worth of food products and live animals, which is good for 17.4% of total good imports (213 million US dollars) (see Fig. 1).

There used to be two main import channels: directly from Venezuela via small boats, or through Curaçao. However, since the economic crisis in Venezuela, the arrival of small boats with fresh food from Venezuela has stopped. Those goods shipped through Curaçao come mainly from the US and the Netherlands although some products originate from Colombia, Ecuador, Brazil, and Argentina (Judge et al. 2014). In the transshipment port of Curaçao, food products are being transhipped from container ships to smaller vessels to be transported to Bonaire. **This import-dependent food system results in relatively high food prices due to import taxes and transport costs, and high vulnerability towards price fluctuations and global and regional developments, and thus represents a major risk to food security on Bonaire.** The downside of relying on import, is clearly shown by the 15% increase in overall consumer prices between 2011 and 2018 on Bonaire (CBS, 2018), which can be largely attributed towards global price developments.

## Trade deficit



## Value of imports, 2017



**Figure 1.** Annual trade deficit on Bonaire in the period 2013-2017 and value of import per category in 2017 (CBS 2018)

### The current practice of extensive husbandry leads to sub-optimal yield and severe erosion.

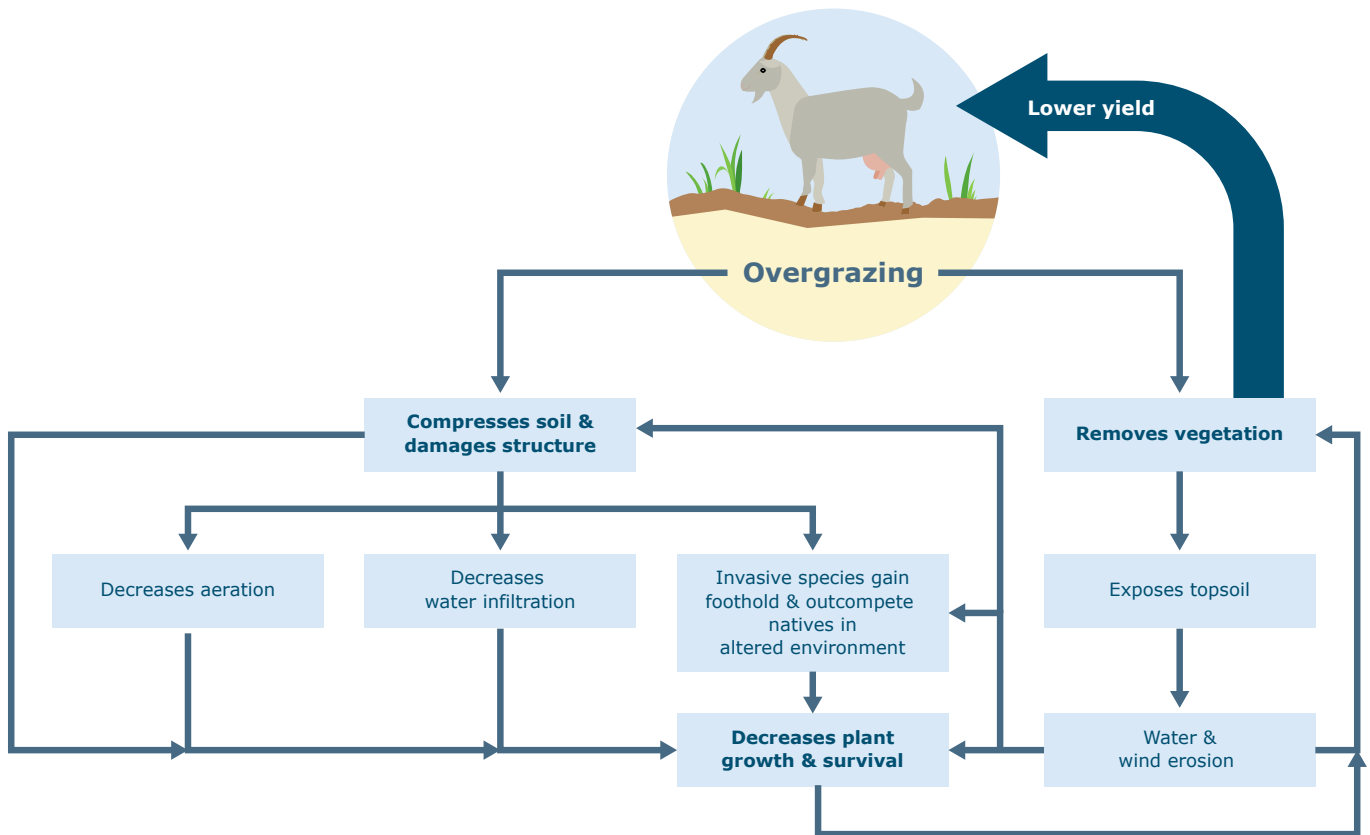
The population of mostly free-roaming goats on Bonaire is calculated to be approximately 32.200, of which roughly 40% are unregistered, without an owner (Lagerveld et al., 2015). Other livestock as sheep, donkeys and pigs also graze freely on the island (with or without owners). Together, this free-roaming livestock consume the island vegetation faster than it can regenerate (Roberts et al., 2017). As a result, vegetation cover and root biomass are decreasing, leading to lower water retention and higher soil erosion rates, which in turn reduce growing conditions for plants, and thus food availability for livestock, which increases grazing pressure on remaining vegetation and subsequent erosion rates (see Fig. 2). Not only does this feedback result in sub-optimal yield from husbandry it also amplifies erosion, with subsequent environmental impact on both the terrestrial and marine ecosystems of Bonaire (Roberts et al., 2017). Apart from damage to the environment, free-roaming livestock also cause economic damage to businesses and private individuals, who have to invest in building fences around yards and plots, and by causing dangerous situations in traffic (Neijenhuis et al., 2015). As such, for society the financial gain of the current practice of extensive animal husbandry is much lower than the financial loss caused by grazing-induced ecological damage.

**On Bonaire, consumption of fresh fruit and vegetables is low**, and diet largely consists of rice, chicken, potatoes and funchi. Beside the relatively

high prices for healthy fresh food, education, upbringing, cultural aspects (agricultural work is associated with the history of slavery and perceived as lower class) perception on food (quality of irrigation water) and changes in availability also contributed to the limited consumption of fresh vegetables and fruit. Consequently, overweight and diabetes are health risk factors that are common on Bonaire (CBS, 2018). Wayaká Advies (2018) provided an estimation on the consumption of fruit and vegetables on Bonaire, based on equivalent values of Curaçao. The estimation is that on average, people consume 100 grams of fruit and vegetables per day, which is much less than the estimated average of 127 gram consumed per person in the Netherlands. Based on a population of 22.000 (locals + tourists) this results in a daily demand of 2.200 kg of fruits and vegetables on Bonaire. Assuming that 50% is derived from tins, cans or freezer, a daily demand of 1100 kg fresh food products is estimated (Wayaká Advies, 2018).

In the Policy Vision 2014-2029 Bonaire (Openbaar Lichaam Bonaire 2014) about agriculture, livestock farming and fishing, several actions are proposed for the coming years. These range from the development of sustainable livestock farming and the allocation of land and treated waste water for production of livestock feed, to an expansion of greenhouses in gardens and the development of specific fisheries legislation. In addition, there is the Rural Development Programme (POP Bonaire) and related

<sup>1</sup>Part of the 2013-2017 Nature Policy Plan "Nature funded projects"



**Figure 2.** Current practice of extensive animal husbandry on Bonaire leads to overgrazing, which causes a series of feedback loops that intensify overgrazing, eventually resulting in suboptimal meat yield and severe habitat degradation.

project funding<sup>1</sup> that consists of 40 projects that are subdivided into four themes: (1) tourism in rural areas, (2) opportunities for entrepreneurs, (3) vegetables from the own garden and a (4) centre for sustainable agriculture. These POP-projects aim at enlarging the local food production, in combination with nature conservation and focus on education of youth, training of entrepreneurs, guidance and commercial business set-up, development of a centre for sustainable agriculture, but so far the lack of strong policy and governance has limited progress of these projects, which even resulted in the Dutch House's adoption of a motion from the MP Bosman to reorganize the Agriculture, Livestock and Fisheries department (LVV) of the local government to make it more effective

(Bosman et al., 2018).

With support from POP Bonaire, a small hydroponic farm has recently started on Bonaire, which has managed to produce affordable crops of lettuce for a competitive price. This water-saving farming technique, reduces water-related production cost of 1 head of lettuce to only 0.04 USD, while the market price for one head of lettuce is 1 USD (pers. comm. Van Almenkerk, Wayaká Advies) and thus provides a great example that investments in sustainable horticulture can also be commercially interesting. In addition to the use of innovative sustainable agricultural technologies, increased food demand as a result of predicted population growth and increasing numbers of visiting tourist, also provides scope for upscaling and commercialization of local food production on Bonaire.

## DESIRED FUTURE STATE & CHALLENGES

The aim is to achieve a sustainable and resilient food system that provides access to affordable, safe, sufficient, and nutritious food for everyone, and that contributes to a more healthy eating pattern. This can be achieved by increasing the local food production system in a sustainable way (note that this also includes sustainable development of fisheries, which is discussed in factsheet “Food from the Oceans”). However, to create the enabling environment for development of this desired sustainable and resilient food system, the following challenges should be taken up:

- Low stakeholder involvement
- Rainfall is unpredictable (periods of drought often result in failed harvest due to limited access to water for irrigation)
- Groundwater is unsuitable for irrigation due to high salinity
- Ongoing sea level rise resulting in salinization of ground water
- Increasing risk of natural disasters
- Limited political priority and limited public support for sustainable development of the agricultural sector
- Low public support for the provision of subsidies to explore the potential of saline agriculture
- Limited access to freshwater, electricity, agricultural equipment, human capacity and agro-technology
- High theft rate in rural area limits investments aimed at agricultural development of the rural area
- Grazing-induced erosion by free-roaming livestock leading to habitat degradation and suboptimal meat yield
- 1% of food is locally produced, while 99% is imported
- Low awareness about benefits for health and environment to eat locally sustainably produced fresh food
- Increasing poverty, resulting in consumption of imported cheap unhealthy processed food

Vegetables that can be produced on Bonaire are lettuce, oca, chard, paprika, pumpkin, spinach, celery, eggplant, tomato, cucumber, cucumber chiki, garter, tajar leaves and herbs. Fruits that can be produced include shimaruku, papaya, kenepa, medlar, hoba, and coconuts. However, there are also crops that are unsuitable for production on Bonaire due to climatic requirements or high production costs and as such need to be imported. These crops include, cabbages, onions, carrots, broccoli, cauliflower, apples, bananas, oranges, and mango. As a result, a 25-40% production in terms of the total demand of fresh food is assumed to be feasible (Wayaká Advies 2018).

## POSSIBLE NEXUS INTERVENTIONS & SYNERGIES

Sustainable development of agriculture and husbandry on Bonaire provides a great opportunity to increase food and nutrition security for current and future generations, but requires a holistic approach that accounts for the inter-dependencies between the Water–Food–Energy–Ecosystem NEXUS domains. In this section, several interventions are presented that will aid sustainable development of the agricultural and livestock sector (i.e. food security), while simultaneously contributing to water, energy, ecosystem and nutrition security.

### Sustainable development of goat farming

To reduce the environmental impact of grazing by approximately 32.000 free-roaming goats, unregistered free-roaming goats should be eradicated, which would leave a population of approximately 16.000 goats (pers. comm. van Almenkerk). By replacing these goats with a more productive goat race (more flesh per animal) (Neijenhuis et al., 2015), by shifting towards lamb production (faster yield), and by keeping goats behind fences where they can be fed with more profitable food (faster yield), the remaining 16000 goats can be reduced to 6000 goats while keeping production rates equal (pers. comm. van Almenkerk). These goats will produce higher quality meat, which can be sold for a higher price. To facilitate this change, land and treated waste water should be made available for open-field production of fodder. To compensate for additional costs related to keeping goats enclosed, this fodder should be sold to goat keepers at subsidized prices. As fodder is of higher quality than natural vegetation consumed by free-roaming goats, it will benefit meat quality and slaughter weight, and the quality of manure. Housing of goats also facilitates feed utilization and allows manure to be collected and sold for use in agriculture. In addition, goat housing will reduce grazing pressure exerted by free-roaming goats, which allows natural vegetation to recover. This will reduce the loss of fresh water, topsoil and nutrients from the terrestrial environment and subsequent negative impact on the coastal ecosystem (see Fig. 3 in factsheet “Ecosystem”).



### **Sustainable development of agriculture**

The scarcity of water and limited access to renewable energy in rural areas are severe challenges for the sustainable development of agriculture on Bonaire. At present, most water retained behind catchment dams is lost to evaporation. As such, the design and development of an effective system for freshwater harvest, (long-term) storage, distribution, and use in agriculture provides a great opportunity to increase crop yield. Likewise, development of an effective system to make treated waste water available for agriculture will also contribute to crop yield. Moreover, the feasibility of using solar-powered groundwater pumping systems in combination with small solar-powered reverse-osmosis units to turn brackish groundwater into freshwater suitable for irrigation, should be explored. At the same time, the use of innovative water-saving agricultural techniques should be facilitated, through subsidies and space allocation for hydroponic farming, saline agriculture and selection of low-water-use crops, and through the development of an agro-business and knowledge centre where information, material and knowledge related to water-saving agriculture can be shared. The development of innovative water-saving agricultural techniques including exploration of production of salt-resistant crops, will likely contribute to agricultural diversification, which will strengthen resilience and productive capacities of the agricultural sector.

Whereas farming requires electricity for irrigation and cooling of products, most farms in the rural area of Bonaire only have limited access to electricity. Facilitation of the use of solar panels by farmers provides an effective way to improve their access to electricity without the need to be connected to the power grid. Moreover, the use of renewable solar energy will make agriculture more sustainable by reducing its carbon food print. Solar panels also provide great opportunities to increase water security when used as collectors of rainwater, and when placed above crops, solar panels can reduce UV stress to crops and reduce evaporation of soils, which both will enhance crop yields. Subsidies and green loans should be provided to stimulate farmers to purchase solar panels.

### **Refocus on domestic markets**

Given ongoing population growth and ever-increasing numbers of visiting tourists, there is much opportunity for agriculture to refocus on domestic markets in order to improve food security and nutrition and advance sustainable development of the rural area. Identifying and realizing real growth market potential in domestic markets, including tourism markets (i.e. quality food production and local branding) and developing production, processing and marketing skills is required to meet the quality and consistency in standards demanded. Exploration of intraregional markets



(Curaçao, Aruba) also represent an opportunity as they enable a faster transition towards new production patterns that could increase equity. Moreover, to increase the utilization of locally produced vegetables and fruit by local people and to increase awareness about diet-related diseases, educational programmes about sustainable and healthy eating should be developed.

### **Increasing human capacity**

Getting young people involved in agriculture and boosting support for farmers is key to improving food security and economic well-being in the medium and long terms. This can be achieved by development of education youth programmes on sustainable agriculture and by encouraging the agricultural sector to provide them internships and apprenticeships. Moreover, a horticultural culture/tradition with local people should build up. All possible by learning in practice, for example by buddying a local for 2 years with an expert in horticulture. Note that in view of the scale of horticulture and hydroponics, not many people need to be trained, because it has to be in balance with market demand. Probably, training of about of 5-6 locals to professional gardeners would allow crop production for the local market in 2.000 to 5.000 m<sup>2</sup> greenhouses (pers. comm. Van Almenkerk)

## GOVERNANCE

**An enabling environment for sustainable development of the agricultural sector is key to achieving and sustaining food security and nutrition on Bonaire.** Creating such an enabling environment requires strong sustained political commitment; effective governance and institutional arrangements including meaningful opportunities for civil society to engage and to hold governments to account; the alignment of processes, policies, legislation, systems, regulations, and investments across sectors and levels; the building and mobilisation of sufficient capacity and resources; and the generation and dissemination of reliable and timely knowledge and evidence (FAO 2017).

The challenge is to implement effective and efficient problem solving policies in ways that are regarded as legitimate by the stakeholders who are involved, enabled, or otherwise directly affected by the decisions and actions undertaken by any governance structure or regime, as well as building and strengthening the capacities of national institutions according to priorities (FAO, 2014). For Bonaire, this involves arriving at a shared set of facts among stakeholders to inform decision-making with regard to sustainable



development of the agricultural sector. A key step towards creating a common vision is to bring the various NEXUS-sectors, stakeholders and institutions together and mainstream objectives and concerns to be achieved through integrated NEXUS-approaches. Strategic decision-making and improved policy development for the agricultural sector of Bonaire is often constrained by isolated, fragmented or missing data. Generation and dissemination of essential data, statistics and information is crucial in order to base policy on evidence rather than perception. Governance as a process of social coordination requires quality assessments and information systems as well as constant monitoring to measure progress. To achieve this it is essential to increase the capacity of institutions responsible for providing food security and nutrition information and consolidating harmonized information systems (FAO, 2014).

Due to the variety of stakeholders involved, governance of the transition towards a self-supporting sustainable food system on Bonaire will be complex. Departments and organisations that play a role in the food sector of Bonaire, including: Department of Agriculture, Livestock and Fisheries (LVV), Boneiru Duradero, Green Bonaire bv, Wayaká Advies, Punta Berde bv, the sewage treatment plant (owned by the local government), Kriabon, Fundashon Forma, Scholengemeenschap Bonaire, Fundashon Krusada, Bona Bista Island Estate, Van Den Tweel Groep, Ministry of Economic Affairs an Climate Policy (via POP), Public Health Service, Rotary Club Bonaire.

## FUTURE PRIORITIES & RESEARCH NEEDED

**Water management plan:** Development and implementation of a water management plan in terms of logistics, water type, spatial and temporal variability in water demand that is aimed at optimization of agriculture without compromising the other dimensions of the water-food-energy-ecosystem NEXUS

**Business case saline agriculture:** The additional value of a business case for saline agriculture is questioned and should be evaluated. Possibilities of saline agriculture conflicts with local acceptance due to felt inequality in allocated subsidies. In addition, groundwater salinity levels on Bonaire are likely to vary in time and space, while saline crops may require constant salinity. Research is needed to investigate the degree of spatiotemporal variability in groundwater salinity levels and how this variability may affect the potential for saline agriculture on Bonaire and the potential environmental impact of saline agriculture on groundwater quality and quantity.

**Monitoring:** Current examples in horticulture and hydroponics show that up to 40% of the vegetable and fruit needs on Bonaire can be grown on the island (Wayaká Advies 2018). As this percentage is likely to be insufficient to achieve a sustainable and resilient food system, more investments are needed to increase local sustainable food production. However, this requires knowledge and quality data on where and how to invest in the development of the sustainable agricultural sector on Bonaire, which are currently lacking. For example, to identify suitable locations for development of agri- and horticulture, data are needed on spatial and temporal differences in soil and water quality, moisture, water management, and site-specific logistics and infrastructure regarding access of effluent water to irrigate. Implementation of environmental monitoring programmes will also contribute to shared fact-finding, which will aid stakeholder involvement. Likewise, research into the possibilities of novel water- and energy-saving agriculture are also required.

**Socio-economic setting:** Through POP-Bonaire, water-saving hydroponics systems and a hydroponic handbook are supplied for a reduced price, which could help to grow vegetables on the household level. However, even small investments for a “Do it Yourself” hydroponic system might not be feasible, and other social-economic factors could limit the potential. Therefore, the acceptance of hydroponics on the household level should be looked into.

**Perception of food quality:** To increase consumption of locally produced fresh food, the widespread perception that locally produced food is of low quality and not good for your health as a result of irrigation with low quality water, should also be looked into. This also requires quality assessments aspects in terms of medicine, hormones of LVV treated waste water

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## Colophon

January 2019

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Reviewer: Dolfi Debrot

Graphic design and lay out: Kinga Bachem

Special thanks go to Franceska Neijenhuis from Wageningen UR Livestock Research for sharing information and her contribution in meetings and to Jan Jaap van Almenkerk of Wayaká Advies for information and organising our field visit.

The KB program "Nexus Strategic policy case", included a Bonaire NEXUS case study. The case study was funded under KB-33-005-013, and administered under project number 4318300087. A letter report (number 1900369.ds) summarises the activities. In the study a set of 8 factsheets was drafted (and attached to the letter report). The set of factsheets can be found on : [www.wur.eu/sustainablewatermanagement](http://www.wur.eu/sustainablewatermanagement)

